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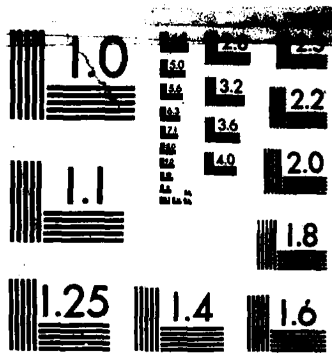

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Report No. CG-D-12-85

A CREW EXPOSURE STUDY - PHASE II
VOLUME II - AT SEA
PART B

W. J. Astleford
J. C. Buckingham
H. L. Kaplan
R. J. Maggot
J. P. Riegel

Final Report
April 1985

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Prepared for:

U.S. Department of Transportation
United States Coast Guard

Office of Research and Development
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A CREW EXPOSURE STUDY – PHASE II
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PART B

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FINAL REPORT
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16. Abstract

The objective of this effort was to implement the Phase I test plan for characterizing occupational exposures of crew members on bulk liquid tankers to chemical substances, primarily cargo vapors. Additional chemical substances included nuisance dust, asbestos fibers, oil mist and silica dust. This report documents the measurement and monitoring data that were collected on six at-sea voyages that involved tankers carrying Subchapter O, Subchapter D and unregulated liquid products. The interpretation of these occupational exposures was based on a conservative method that makes use of the medical monitoring response level concept and current values of the ACGIH TLVs. This method was developed because the work routine that forms the basis for TLVs is not generally applicable to marine operations. Noise dosimetry was performed on two voyages in order to characterize the environment in an Engine Room and in the Deck Department of a state-of-the art product tanker.

This study concluded that the potential for unacceptable inhalation exposures is greatest during open tank gauging and entry into product tanks. Volume II, Part A represents the body of the Final Report. The detailed voyage reports are contained in Volume II, Part B. Keywords

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Tankers, Chemicals, Crude Oil, Deck Department, Marine Transport, Vapors, Occupational Exposures, Noise, Engine/Pump Room.

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APPENDIX A

VOYAGE REPORT - VOYAGE 1

VOYAGE 1 REPORT OUTLINE

I. <u>Vessel Description</u>

I.1 Dimensions
- o Length Overall - 630 ft
- o Length between perpendiculars - 600 ft
- o Breadth (mid) - 100 ft
- o Depth (mid) - 45 ft

I.2 Tonnage - 39,000 DWT (summer mark)

I.3 Propulsion - 14,000 hp diesel

I.4 Cargo Tanks - 18 (six rows of three across, wing capacities symmetric about center longitudinal)

I.5 Cargo Pumps - five 4500-gpm self priming, diesel driven deepwells; one 2500-gpm self priming diesel driven deepwell

I.6 Cargo Loading Method - open drop, open loading

I.7 Cargo Gauging Method - open gauging with Lufkin tape and crucifix through deck riser tubes. The deck riser tubes extend 28 in. upward from the deck plate. Tube inside diameter is 8 inches. The gauging tubes are not classified as a restricted gauging system.

I.8 Vapor Venting System - Vapors are vented through open ullage ports and open riser tubes during loading. Vapors are vented from secured tanks through VAC-REL P/V valves on each expansion trunk. The pressure-vacuum settings are 1.0 psi and 0.5 psi, respectively. The center of the P/V valve discharge is 42 in. above deck level.

I.9 Tank Cleaning Method - non-rotating water spray nozzle and water driven air blowers.

I.10 Expansion Trunk Layout - The expansion trunks for the starboard wing tanks are colinear and parallel with the ship's longitudinal axis on the starboard side. The expansion trunks for the center tanks are colinear, as are the port wing trunks, both sets being located on the port side of the vessel.

II. Deckhouse Configuration and Ventilation

II.1 Deckhouse Configuration

The deckhouse consisted of three levels:

1. Main deck level - housed the galley, mess, engine control room, and quarters for unlicensed crew members.
2. Boat deck level - housed the hospital room and quarters for the licensed crew members.
3. Navigation bridge.

Access to the deckhouse from the forward deck was provided by two doors (port and starboard) on the main deck level and one door on the boat deck. Three doors, similarly located, provided access to the stern deck.

II.2 Deckhouse Ventilation

Conditioned air was provided to the main and boat deck areas by a central, closed-return heating and cooling unit. The compressor for the cooling unit was housed in the engine room. Air discharge grills were located in the ceilings of individual rooms with return air grills located in the interior doors.

Although the system had the capability of drawing in fresh air from the boat deck, this duct was normally kept shut. Therefore, the air conditioning system should not communicate with the outside ambient air unless the external air infiltrates into the deckhouse through the access doorways. This same system provided air conditioning to the bridge, where a window unit was also located. Due to the mild temperatures, the doors to the bridge wings were normally open.

An exhaust fan was located in the galley over the grill. This was strictly an exhaust fan with no makeup air capabilities.

III. Engine Room Configuration and Ventilation

III.1 Engine Room Configuration

The engine room consisted of four levels, the first one being a level below the main deck. The control room was located on the main deck level in the very front of the deckhouse and centrally located between the forward deck access doors.

III.2 Engine Room Ventilation

Primary ventilation for the four-level engine room was provided by a push-pull system. Supply air was provided by two separate blowers, whose inlets were located on the central surfaces of the fairing supports for the flying bridge. Exhauster discharge grills were located on the aft end of these fairings.

Supply air was ducted to the first and second below-deck levels in the engine room. Forced ventilation for the forward third level was provided by one of the second level supply ducts located directly over the diesel engine. Air from the second level was transported to the third level through open floor gratings. Forced ventilation was confined primarily to the forward portions of the engine room that housed the main engine and other heat-producing pieces of equipment. The aft end of the first level, which housed the hydraulic steering mechanism as well as a welding shop and a general work shop, was separated from the forward portion of the engine room by a bulkhead with a hatch for access. Ventilation for this room consisted of infiltration through the door and natural ventilation as provided by a vertical duct that opened onto the main deck level aft of the deckhouse. The third and fourth levels housed the clutch, reducer gear assembly, and the drive shaft. A mechanical ventilation outlet was located over the propeller shaft assembly.

IV. Cargo Description

The cargo consisted of jet fuel and regular, unleaded, and super unleaded gasoline. During loading, these products were distributed according to Table I.

TABLE I. CARGO DISTRIBUTION PLAN

Tank No.	Quantity (bbls)	Product
1P	12,800	Super Unleaded Gasoline
1C	28,410	Super Unleaded Gasoline
1S	12,800	Super Unleaded Gasoline
2P	14,200	Regular Gasoline
2C	22,350	Regular Gasoline
2S	14,200	Regular Gasoline
3P	18,730	Unleaded Gasoline
3C	39,680	Unleaded Gasoline
3S	18,730	Unleaded Gasoline
4P	13,080	Jet Fuel
4C	27,720	Jet Fuel
4S	13,080	Jet Fuel
5P	9,330	Jet Fuel
5C	15,580	Jet Fuel
5S	9,250	Jet Fuel
6P	8,450	Unleaded Gasoline
6C	18,260	Unleaded Gasoline
6S	8,450	Unleaded Gasoline

These products were subsequently discharged in two ports. The port times for loading and discharge are noted below.

Port No.	Operation	Duration (hrs)
1	Loading	32.0
2	Discharge	12.0
3	Discharge	52.5

V. Watch Composition and Work Schedules

Excluding the Master, the Deck Department consisted of three licensed Mates and six unlicensed personnel (i.e. A/B's and O/S's).

At sea, all three Mates stand a 4-on, 8-off navigation watch. During off-watch hours at sea, each Mate may perform additional work activities on an overtime basis, if he so chooses. In part, the Mates stand a 4-on, 8-off deck watch during cargo transfer. Overtime work is also conducted off-watch. This overtime work may include "all hands" in preparation for docking and undocking, extending the deck watch hours if the Chief Mate's work load is too great, especially during the critical stages of cargo handling, and a variety of maintenance and housekeeping tasks.

At sea, the A/Bs stand a navigation watch. In port, they stand deck watches. The watch shifts of the three A/Bs were scheduled such that they could also work a full 8-hour maintenance and repair shift. Opportunities for overtime exist such as mandatory "all hands" for docking and undocking if it occurs outside of the regular work hours and assisting with heel washing of tanks and flushing of cargo discharge lines. The A/Bs are required to work a "bow watch" during channel navigation. This requires them to work 2 hours after their normal 4-hour shift.

The O/Ss do not stand navigation watch. At sea, they perform deck work and general maintenance (0800-1700) as directed by the Bosun, who received his daily work list from the Chief Mate. In port, the O/Ss stand deck watches. The O/S also has opportunities for overtime such as "bow watch" during channel navigation and tank cleaning work at night or engine room maintenance. For "bow watch" the O/S must report 2 hours before his regular 4-hour shift. While in port, the deck watch work unit consists of a Mate, an A/B, and an O/S.

It is to be noted that all work schedules include frequent, short, rotating work breaks for rest and mess time.

VI. Trip Overview

According to the test plan, two Deck Department employees were to be identified for the monitoring program. Based on the desire to monitor individuals that would be primarily involved with cargo transfer operations and most especially tank topoffs, the third mate (3/M) and his corresponding A/B (A/B1), both on the 0800-1200 and 2000-2400 shift, were chosen. The work activities and occupational exposures for these two individuals were monitored during the entire voyage.

When the two selected employees were either off duty or in an environment where occupational exposure information was not warranted (based on OVA surveys), the activities of other workers were monitored. This enabled documentation of a wider range of work activities and additional information for activities of particular interest.

Figure 1 presents the durations of terminal dockings as well as the regular work shifts of the 3/M and A/B1 for the entire twelve-day voyage. As is noted in this figure, the trip consisted of loading at one terminal, discharge at two terminals, and return to the loading terminal. Time gaps between terminals represent transit times from one berth to the next.

The major deck work activities for each day of the voyage are listed in Table II. The work activities and occupational monitoring of these documented activities for the 3/M, A/B1, and the various additional employees are thoroughly presented in Section VIII, IX, and X, respectively.

TABLE II

Day	Major Deck Work Activites
1	Periodic tank gauging, tank topoffs
2	Periodic tank gauging, tank topoffs
3	Post-loading deck work
4	Rust chipping, painting
5	Rust chipping, painting
6	Discharge gauging, ballasting
7	Rust chipping, painting
8	Discharge gauging
9	Discharge gauging, ballasting
10	Rust chipping, painting
11	Washing and blowing all wing tanks
12	Pre-loading deck work

Topoff of 4P

The topoff of 4P was completed using a crucifix. The ullage readings are summarized below:

Encounter No.	Time	Duration (sec)
1	0957:00	10
2	1002:40	6
3	1005:00	5
4	1006:50	2
5	1007	180
	1010	Stopped 4P

Topoff of 4S

The topoff of 4S was completed using a tape and then the crucifix. The ullage readings are summarized below:

Encounter No.	Time	Duration (sec)
Using tape		
1	1013	
2	1019	5
3	1020	10
4	1025	2
5	1028:30	8
Using crucifix		
6	1031:35	7
7	1032:40	5
8	1033:31	3
9	1033:50	3
10	1034:00	3
11	1034:10	3
12	1034:25	3
13	1034:45	3
	1034:55	Stopped 4S

Topoff of 4C

The topoff of 4C was completed using a crucifix. The ullage readings are summarized below:

Encounter No.	Time	Duration (sec)
1	1042:00	3
2	1043:00	3
3	1044:00	3
4	1045:00	3
5	1045:17	3
6	1045:47	3
	1046	Stopped 4C

Topoff of 2C

Tank 2C was short loaded and stopped at an ullage of 10 feet. The readings were taken with a regular ullage tape and are summarized below.

Encounter No.	Time	Duration (sec)
1	0804:30	15
2	0805:48	12
3	0806:50	10
4	0809:40	7
5	0811:30	8
6	0814:40	10
7	0816:40	10
8	0817:50	15
9	0818:46	38
10	0819:55	10
11	0820:30	3
12	0821:00	4
13	0821:50	4
14	0822:23	9
15	0822:48	7
	0823	Stopped 2C

All of these ullages were taken from the upwind side of the deck riser.

Topoff of 6C

Tank 6C was topped off using first a tape and then a crucifix. A summary of the ullages is given below.

Encounter No.	Time	Duration (sec)
Using tape		
1	0851:30	3
2	0857:17	31
3	0901:20	23
4	0902:08	15
5	0902:30	13
6	0903:00	4
7	0904:00	4
8	0904:40	5
Using crucifix		
9	0908:40	8
10	0909:25	5
	0910	Stopped 6C

Deck Watch Period 2 (0800-1200, Day 2)

The major activities during this period were tank topoffs and periodic tank gauging. Exposure monitoring samples were collected to correlate with specific activities as summarized below.

Time	Activity	Sample Number
0800-0830	Topoff of 2S, 2C	SB-42 60385
0830-0915	Topoff of 6C	SB-60 60386
0915-1050	Topoff of 4P, 4S, 4C	SB-48 60387
1050-1200	Periodic Tank Gauging	SB-49

The following summarizes the specific details of these activities, i.e. the topoffs and tank gaugings.

Topoff of 2S

Tank 2S was to be filled to a 98% full ullage of 3'8". The tank topoff procedure when filling a tank to an ullage of less than four feet, as measured from the 28" high deck riser, was accomplished using a wooden crucifix. The shaft that extended into the tank was about four and one-half feet long and the cross piece was long enough to rest on the deck riser. Once the product level reached the bottom of the stick, this crew member never moved more than three feet away from the riser. Little time was spent with the breathing zone directly over the top of the riser. He was usually there just long enough to drop the crucifix in and then pull it out. He would then step back, standing upwind or crosswind, and look at the liquid level mark on the stick.

The series of ullage measurements during topoff of tank 2S are listed below:

Encounter No.	Time	Duration (sec)
1	0756:40	5
2	0757:08	4
3	0757:30	3
4	0757:40	2
5	0758:30	2
6	0759:11	7
	0759:20	Stopped 2S

All of these ullages, except for Encounter No. 1 which was taken from downwind, were taken from crosswind of the deck riser.

Start Time of Round	Tank	Duration (sec)	Breathing Zone Vapor Conc. (ppm gasoline)
2158	6S	20	300
	6C	30	415-700
	6P	15	45-65
	3P	17	1750-2000
	3C	14	4300
	3S	20	1500
2229	4S	56 F*	16-115
	4C	60 F	115
	4P	30 F	730
	5P	40	160-480
	5S	30 F	70-6000
	5C	20	NM **
2258	6P	20 F	NM
	6C	20 F	NM
	6S	20 F	NM
	3S	25 F	NM
	3C	15 F	NM
	3P	20 F	NM
2329	5S	16	NM
	5C	21	NM
	5P	27	NM
	4P	27	NM
	4C	30	NM
	4S	32	NM
	2S	20	NM
	1S	26	NM

The 3/M's body position was usually either upwind or crosswind of the deck riser during ullage readings, but he sometimes stood downwind because of convenience.

For the time between periodic rounds, the 3/M sat or stood at various placed on the deck. These locations included:

- o the starboard rail upwind of the vapors,
- o the 4S hatch cover facing stern (downwind of the vapors from the open ullage cap on the expansion trunk), and
- o the steps downwind of the starboard manifold drip tray.

* F indicates that 3/M held flashlight for A/B taking actual ullage reading.
** NM indicates not measured.

TABLE III. SUMMARY OF ACTIVITIES AND EXPOSURES FOR THE 3/M (CONTD)

WORKER TITLE: 3rd Mate (Page 3 of 3)

WATCH: 0800-1200, 2000-2400

Voyage Day	Voyage Leg	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration ppm Benzene	Exposure Concentration ppm Gasoline	Exposure Duration (min)
10	Ballast	In Deckhouse	0000 - 0200	OFF	None	None	--	--	--
		Wheelhouse for Maneuvering	0200 - 0400	OT	None	None	--	--	--
		In Deckhouse	0400 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1300	OFF	None	None	--	--	--
		Fire Line Maint.	1300 - 1700	OT	None	None	--	--	--
		In Deckhouse	1700 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
11	Ballast	In Deckhouse	0000 - 0600	OFF	None	None	--	--	--
		Wheelhouse Relief for C/M	0600 - 0800	OT	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 2000	OFF	SB-9	Gasoline Infiltration	ND	1.08	247
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
12	Ballast	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1300	OFF	None	None	--	--	--
		General Pump Maint.	1300 - 1500	OT	None	None	--	--	--
		Wheelhouse for Maneuvering	1500 - 1600	OT	None	None	--	--	--

TABLE III. SUMMARY OF ACTIVITIES AND EXPOSURES FOR THE 3/M (CONTD)

WORKER TITLE: 3rd Mate (Page 2 of 3)

WATCH: 0800-1200, 2000-2400

Voyage Day	Voyage Leg	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration		Exposure Duration (min)
							ppm Benzene	ppm Gasoline	
5	Laden No. 1	In Deckouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1530	OFF	None	None	--	--	--
		General Pump Maint.	1530 - 1700	OT	None	None	--	--	--
		In Deckhouse	1700 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
6	Laden No. 1	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
	Disch. No. 1	In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
	Laden No. 2	Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
7	Laden No. 7	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1330	OFF	None	None	--	--	--
		General Pump Maint.	1330 - 1500	OT	None	None	--	--	--
		In Deckhouse	1500 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
8	Discharge No. 2	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Discharge Gauging and 2P, 2S Stripping	0800 - 0930	RT	SB-78	Gasoline Vapors	ND	5.16	94
		Discharge Gauging	0930 - 1200	RT	SB-109	Gasoline Vapors	ND	18.88	125
		In Deckhouse	1200 - 2000	OFF	SB-116	Gasoline Vapors	0.11	2.17	488
		Discharge Gauging	2000 - 2400	RT	SB-102	Gasoline Vapors	ND	8.02	240
		Stripping of 6S	2100 - 2200	RT	SB-31	Gasoline Vapors	ND	8.91	65
9	Discharge No. 2	In Deckhouse	0000 - 0800	OFF	SB-33	Gasoline Vapors	ND	ND	420
		Discharge Gauging	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
	Ballast	Ballast Gauging	2000 - 2400	RT	SB-111	Gasoline Vapors	1.11	122.23	231

TABLE III. SUMMARY OF ACTIVITIES AND EXPOSURES FOR THE 3/M

WORKER TITLE: 3rd Mate (Page 1 of 3)

WATCH: 0800-1200, 2000-2400

Voyage Day	Voyage Leg	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration ppm Benzene	Exposure Concentration ppm Gasoline	Exposure Duration (min)
1	Loading	Periodic Tank Gauging	2000 - 2250	RT	SB-47	Gasoline Vapors	1.18	107.00	177
					60382	Gasoline Vapors	ND	82.88	183
		Periodic Tank Gauging	2250 - 2400	RT	SB-50	Gasoline Vapors	1.19	296.12	57
					60383	Gasoline Vapors	ND	265.83	54
2	Loading	In Deckhouse	0000 - 0800	OFF	SB-64	Gasoline Infiltration	0.18	19.22	483
		Tank Topoff 2S, 2C	0800 - 0830	RT	SB-42	Gasoline Vapors	20.80	4839.10	31
					60385	Gasoline Vapors	19.72	5758.70	39
		Tank Topoff 6C	0830 - 0915	RT	SB-60	Gasoline Vapors	16.49	2997.10	47
					60386	Gasoline Vapors	13.61	4367.30	47
		Tank Topoff 4P, 4S, 4C	0915 - 1050	RT	SB-48	Gasoline Vapors	0.67	81.32	88
					60387	Gasoline Vapors	ND	129.71	85
		Periodic Tank Gauging	1050 - 1200	RT	SB-49	Gasoline Vapors	ND	4.96	56
		In Deckhouse	1200 - 2000	OFF	SB-44	Gasoline Infiltration	ND	1.21	481
		Prepare to Sail	2000 - 2400	RT	None	None	--	--	--
3	Laden No. 1	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
4	Laden No. 1	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1300	OFF	None	None	--	--	--
		General Pump Maint.	1300 - 1700	OT	None	None	--	--	--
		In Deckhouse	1700 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--

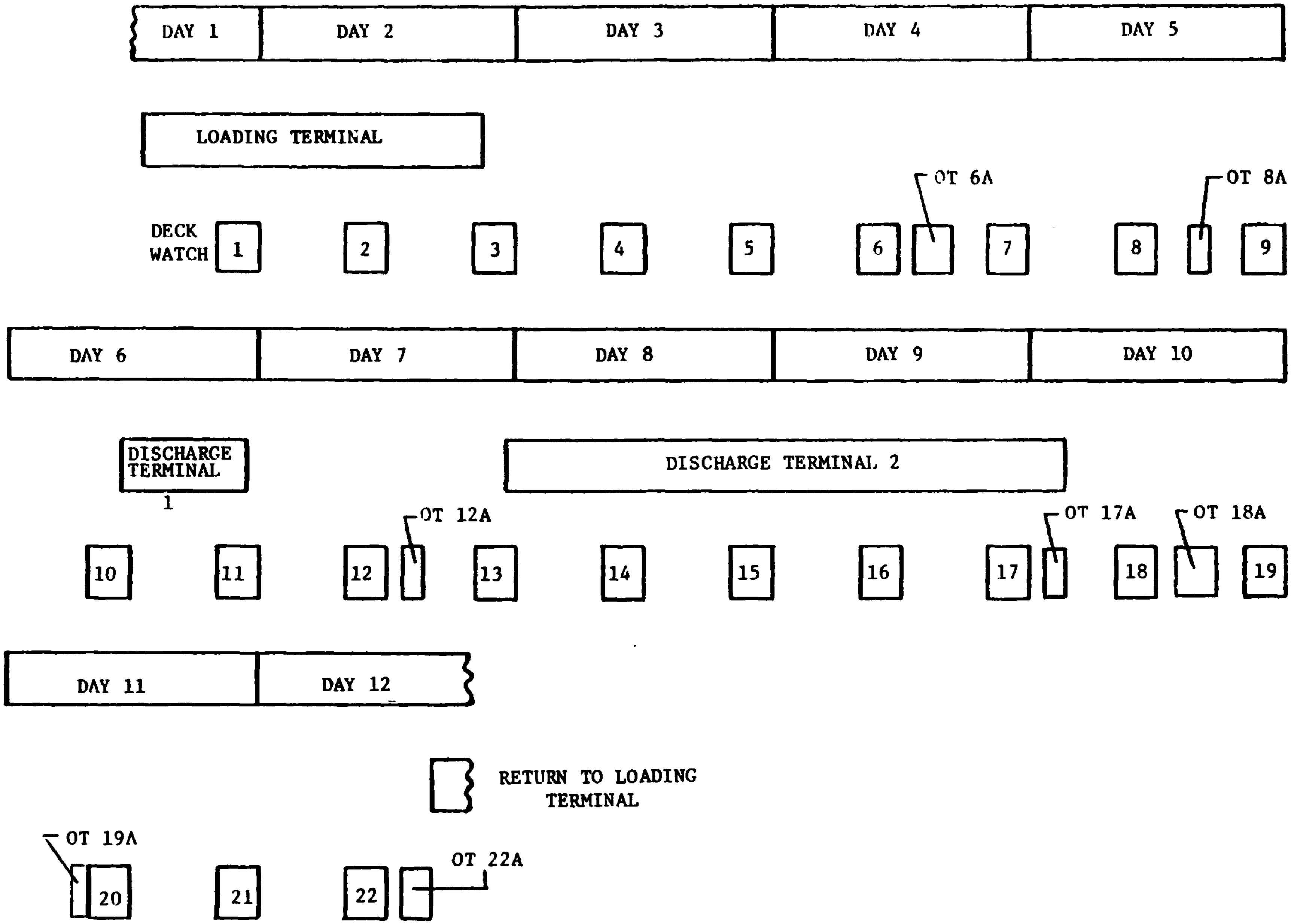

FIGURE 2. REGULAR AND OVERTIME WORK SHIFTS FOR 3/M

VIII. Summary of Activities and Occupational Exposures for the 3/M

The 3/M's normal watch hours were 0800-1200 and 2000-2400. These regular work shifts as well as overtime worked by the 3/M are presented and labelled in Figure 2.

Table III summarizes the 3/M's activities during the entire voyage. For each activity, the time of observation and whether it was regular time (RT), overtime (OT), or off period (OFF) are noted. For times when samples were collected, the sample numbers, exposures, exposure concentrations, and durations are also tabulated.

The activities and occupational exposures for the 3/M during the entire voyage will be discussed in detail in this section.

Deck Watch Period 1 (2000-2400, Day 1)

The loading of regular, unleaded, and super unleaded gasoline into tanks 1, 2, 3, and 6 across had begun at 1930. The loading of jet fuel into tanks 4 and 5 across began at 2000.

The major activity of the 3/M during this watch was periodic tank gauging. Since it was so close to the beginning of loading, very few ullage readings were taken. Two sequential exposure samples were taken during this shift and are summarized below.

Time	Activity	Sample Number
2000-2250	Periodic Tank Gauging	SB-47 *
		60382 **
2250-2400	Periodic Tank Gauging	SB-50
		60383

Gauging rounds usually involved two people, especially at night when use of a flashlight was necessary. The gauging rounds for the 3/M during watch period 1 are summarized below.

* SB-xx indicates active charcoal tube samples

** A five digit number indicates passive charcoal badge samples

Respirable sandblasting exposure samples were collected using a cyclone separator and 37 mm, 0.8 μ MEC filters in cassettes. Sampling flow rate was nominally 1-1.5 Lpm

The filter media was not appropriate to quantitative X-ray diffraction or colorimetric analysis as recommended by NIOSH. Therefore, the following semi-quantitative analysis procedure was employed.

- o A bulk sample of the sandblasting feed stock and a rafter sample (sandblasting debris) were both analyzed sequentially for

  - weight loss upon dehydration at 110°C,
  - weight loss on ignition to remove organics, and
  - weight loss on Aqua Regia treatment to remove non-silica inorganics.

- o This analysis indicated that the feed stock was 99.71 percent silica by weight and that the rafter sample was 99 percent silica by weight (one percent contamination).

- o The feed stock was then analyzed by X-ray diffraction, without internal standards, over the emission range of quartz, tridymite and cristobalite. Only quartz was detected.

Based on the above analyses, it was assumed that quartz was the only silica compound on the respirable sandblasting filters, and it was present on the filter in the same proportion by weight as was determined from the rafter sample (99 percent).

The exposure filters were weighed, and the quartz exposure concentrations were calculated as follows.

$$C = \frac{0.99\ (W_F - W_I)}{Qt}$$

where W_F = weight of respirable material (quartz plus debris) on the filter plus filter weight

W_I = pre-test filter tare weight

Q,t = as defined earlier.

- <u>Passive Dosimeters</u>

$$C\ (ppm) = \frac{\left[W_{CF} + 2.2\ W_{CB}\right]}{\eta(SR)\ t}\left(\frac{24.45}{MW}\right)\left(\frac{T + 273}{298}\right)\left(\frac{760}{P}\right)$$

where

W_{CF} = weight of analyte on exposed front strip corrected for blank, ng

W_{CB} = weight of analyte on backup strip corrected for blank, ng

SR = passive sampling rate, cm^3/min.

(= 35.6 for benzene and 21.9 for gasoline according to manufacturer's data)

Other quantities are as defined for the adsorbent tubes.

Respirable paint and rust chipping samples were collected using (1) a cyclone separator having a 10 μ cutoff on particle size, and (2) filter cassettes containing 37 mm, 0.8 μ MEC filters. All filters were conditioned and weighed prior to sampling. Sampling flow rate was within the accepted 1-2 Lpm range. The Material Safety Data Sheets for the paint primer, thinner and finish coat did not include the presence of chromates, lead, barium or strontium compounds. Therefore, the contaminants of interest were identified as zinc and iron.

Visually, all of the chipping sample filters had extremely light loading. Therefore, a two-step analysis procedure was defined.

- The most heavily loaded filter was weighed, and the exposure concentration was calculated. If the concentration was less than 5 mg/m^3, which is the TLV-TWA for respirable nuisance zinc oxide dust and iron oxide, then the remaining filters would be analyzed gravimetrically.

- If the most heavily loaded filter produced an exposure concentration greater than 5 mg/m^3, then all filters would be analyzed by atomic absorption to quantify the zinc and iron levels according th NIOSH Method P&CAM 173.

In the final analysis, all filters were analyzed gravimetrically, and exposure concentrations were calculated as follows:

$$C = \frac{(W_F - W_I)}{Qt}$$

where W_F = post-test weight of conditioned filter

W_I = pre-test filter tare weight

Q = sampling flow rate

t = sampling time.

- **Charcoal Sampling Tubes**

Chemical	Tube Size	η
Benzene	small (100/50)	0.984
	large (400/200)	0.984
THC(gasoline)	small (100/50)	1.005
	large (400/200)	0.950
Isobutanol	large (400/200)	0.82
MEK	large (400/200)	0.801
MIBK	large (400/200)	0.880
N-Butanol	large (400/200)	0.88
Xylene	large (400/200)	0.981

- **Passive Charcoal Badges**

Chemical	η
Benzene	0.947
THC(gasoline)	1.010

Ambient vapor concentrations were calculated using the following analytical expressions.

- **Absorbent tubes**

$$C\ (\text{ppm}) = \frac{W_c}{\eta Q t}\left(\frac{24.45}{MW}\right)\left(\frac{T + 273}{298}\right)\left(\frac{760}{P}\right)$$

where

W_c = cumulative weight of analyte on the tube corrected for blank, µg

η = desorption efficiency as a decimal

Q = sampling flow rate, LPM

t = sample duration, min.

MW = analyte molecular weight

T = sampling temperature, °C

P = sampling barometric pressure, mm Hg

VII. Sampling Strategy and Sample Analysis

All of the products that were loaded and discharged during the observation period were various types of gasolines. Since there is no recommended NIOSH sampling procedure for gasolines, the sampling was based on b nzene. The recommended NIOSH sampling procedure for benzene is as follows:

TWA (1)	10ppm
Ceiling (1)	25ppm
NIOSH Method Number (2)	S311
Absorbent Type	Activated Charcoal
Absorbent Size	L = 7cm OD/ID = 6/4 mm 20/40 mesh 100/50mg

TWA Concentration:	Sample Volume	12ℓ
	Sample Flow Rate	0.2ℓ/min
	Sample Time	60 min
Ceiling Concentration:	Sample Volume	2ℓ
	Sample Flow Rate	0.2ℓ/min
	Sample Time	10 min

In addition to the conventional sampling methods that employ pumps and tubes, passive dosimeters were also utilized. The badges contained two adsorption elements; one element served as a backup section. All tubes and passive dosimeters were analyzed by an AIHA accredited laboratory.

For the gasoline samples, nitrobenzene was used to desorb the charcoal tubes because it is superior to carbon disulfide in two areas and has desorption efficiences comparable to carbon disulfide. No temperature program was needed for nitrobenzene, and greater analytical precision was possible since no gasoline peaks are obscured, as is the case when carbon disulfide is used. Nitrobenzene was not used to desorb the badges since it dissolved a component of the badge material.

For the paint samples, carbon disulfide was used to desorb the charcoal tubes, as recommended by NIOSH. No badges were used to monitor paint exposure.

The following summarizes the desportion efficiencies reported by the laboratory.

(1) ACGIH Exposure Limits
(2) NIOSH Manual of Analytical Methods, Volumes 1-7.

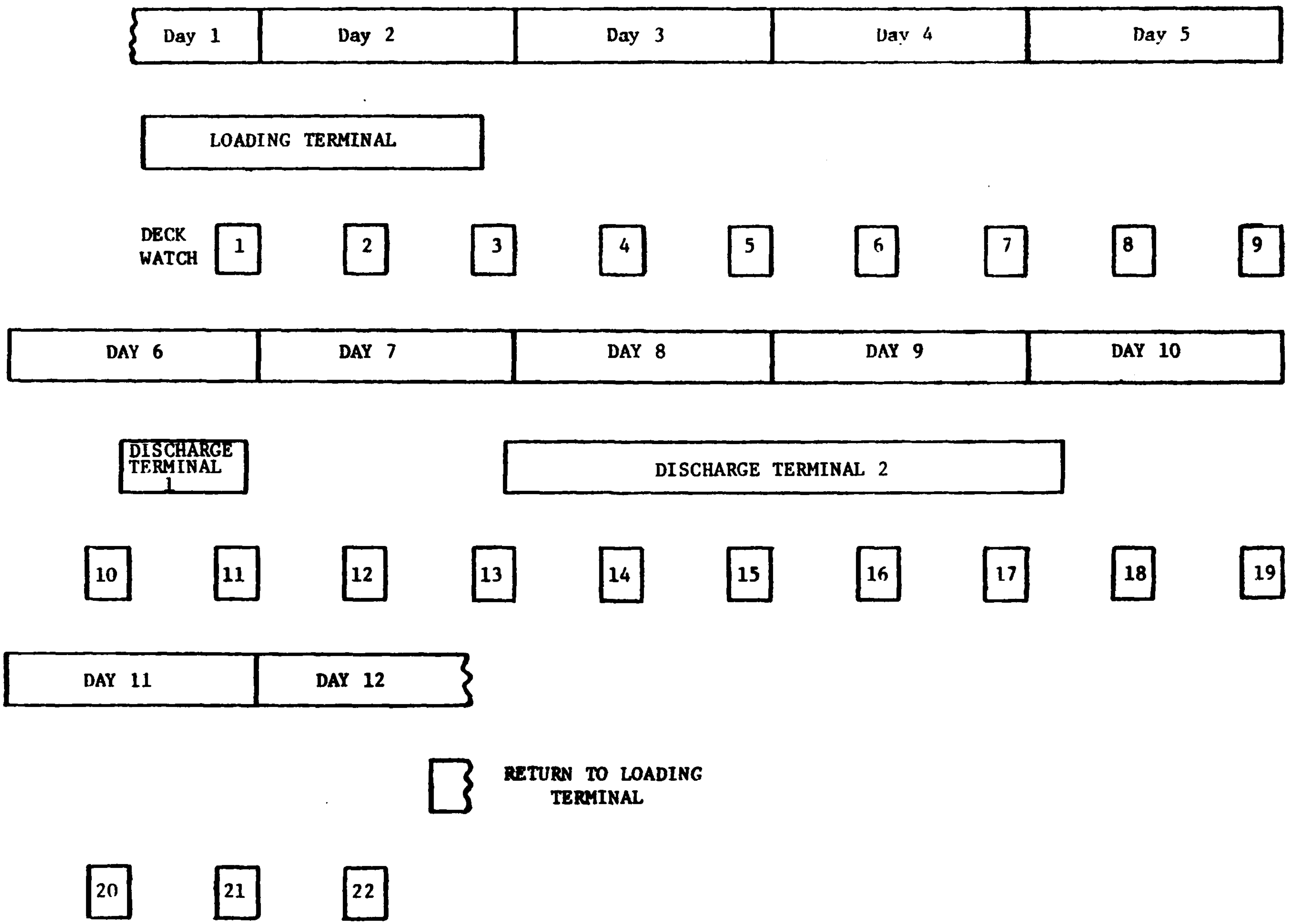

FIGURE 1. DURATION OF TERMINAL DOCKINGS AND REGULAR WORK SHIFTS

At 1100 of this shift, the 3/M completed one ullage round of tanks 3C, 3S, and 3P, then went into the deckhouse to recalculate finishing times of the various tanks and take a break. From 1130 until the end of the shift he was on the deck but in areas where he had little potential for exposure.

<u>Deck Watch Periods 3</u> (2000-2400, Day 2)
<u>4</u> (0800-1200, Day 3)
<u>5</u> (2000-2400, Day 3)
<u>6</u> (0800-1200, Day 4)
<u>7</u> (2000-2400, Day 4)
<u>8</u> (0800-1200, Day 5)
<u>9</u> (2000-2400, Day 5)

The major activity for Period 3 was to prepare the ship's bridge for sailing. This included updating books and preparing charts. Occupational exposure monitoring was not performed on this shift because of the lack of potential for exposure, based on OVA survey information.

The deck watches for periods 4 thourgh 9 were spent entirely in the wheelhouse navigating. Occupational exposure monitoring was also not performed for these six shifts.

<u>Overtime Periods 6A</u> (1300-1700, Day 4)
<u>8A</u> (1530-1700, Day 5)

During these overtime periods, the 3/M performed maintenance activities on the diesel pumps on deck in preparation for discharge. His activities included checking water and oil levels and adding ethylene glycol. Exposure monitoring was not justified based on an OVA survey of the areas in which the 3/M worked.

<u>Deck Watch Period 10 (0800-1200, Day 6)</u>

From 0800-1030 the 3/M was in the wheelhouse for maneuvering and docking activities. He then went out onto the deck to start the cargo transfer. His major activities included preparing valves for discharge, starting the diesels, and engaging pumps when the dock was ready for the transfer to begin. Exposure monitoring was not performed during this period because the 3/M was not near any of the open tanks and ambient concentrations were low during the short time he spent on deck.

<u>Deck Watch Periods 11</u> (2000-2400, Day 6)
<u>12</u> (0800-1200, Day 7)
<u>13</u> (2000-2400, Day 7)

The deck watches for periods 11, 12, and 13 were spent entirely in the wheelhouse navigating. Occupational exposure monitoring was not performed because of the lack of potential for exposure.

Overtime Period 12A (1330-1500, Day 7)

General maintenance on the deck diesel pumps, as discussed for periods 6A and 8A, was performed during this period. Exposure monitoring was again not justified.

Deck Watch Period 14 (0800-1200, Day 8)

The major activities during this period were discharge gauging and the stripping of two tanks. Exposure monitoring samples were collected to correlate with specific activities as summarized below.

Time	Activity	Sample No.
0800-0930	Discharge Gauging and Stripping of 2P and 2S	SB-78
0930-1200	Discharge Gauging	SB-109

A summary of the periodic ullage readings taken between 0800 and 0930 is presented below.

Tank	Time	Duration (sec)
1P	0832:30	36
1C	0833:25	95
1S	0835:20	40
5C	0844:00	20
6S	0845:30	13
2P	0859:24	26

Stripping of product tanks was achieved by looking down into either a Butterworth opening or the ullage hatch and watching the liquid level in relation to the suction lines in the bottom of the tank. Various valves were opened or closed in an effort to pump the maximum amount of liquid out of the tank without losing suction on the pump.

A summary of the times when the 3/M was looking into the tanks to strip 2P and 2S is listed below.

Stripping of 2P

Encounter No.	Time	Duration (sec)
1	0905:30	30
2	0906:10	30
3	0906:45	25
4	0907:30	40
5	0908:30	60
6	0910:00	17
7	0910:36	78
	0912:00	Stopped 2P

Stripping of 2S

Encounter No.	Time	Duration (sec)
1	0912:30	30
2	0913:22	10
3	0913:35	25
4	0914:47	8
5	0915:20	16
6	0915:52	13
7	0916:35	4
8	0916:58	22
9	0917:30	22
10	0918:00	9
11	0918:22	8
12	0919:45	25
13	0920:25	4
14	0920:45	5
15	0922:00	16
16	0923:07	13
17	0924:14	17
18	0924:35	12
19	0924:52	14
20	0925:10	15
21	0925:28	14
22	0925:52	16
23	0926:10	17
24	0926:30	20
	0927:00	Stopped 2S

A summary of the periodic ullage readings taken between 0930 and 1200 is presented below.

Tank	Time	Duration (sec)
6S	1005:50	25
6C	1006:25	23
6P	1007:18	32
5P	1008:20	30
5C	1009:20	18
5S	1009:53	30

Only minimal gauging was necessary because this shift was so close to the beginning of discharge, and most of the tanks were still over half full. These gaugings were mainly for determining discharge rates which were used to calculate the ship departure time.

Deck Watch Period 15 (2000-2400, Day 8)

Although there were many tanks discharging simultaneously during this watch period, the only gauging that was done was to strip 6S. Two different exposure samples were collected, one over the entire shift and one during the hour that it took to strip 6S. These samples are summarized below.

Time	Activity	Sample No.
2000-2400	Discharge Gauging	SB-102
2100-2200	Stripping of 6S	SB-31

The following summarizes the times when the 3/M was looking into 6S for stripping.

Stripping 6S

Encounter No.	Time	Duration (sec)
1	2102:35	10
2	2105:00	10
3	2115:00	45
4	2125:20	47
5	2130:50	50
6	2135:00	60
7	2142:36	34
8	2144:00	30
9	2144:40	6
10	2146:00	29
11	2146:33	38
12	2156:20	10
13	2158:00	120
	2200:00	Stopped 6S

Deck Watch Period 16 (0800-1200, Day 9)

The major activity during this watch period was discharge gauging. Exposure monitoring was not conducted because it was raining and the high humidity can cause invalid results. Also, OVA surveys indicated that there was little potential for exposure.

Deck Watch Period 17 (2000-2400, Day 9)

The major activity during this shift was ballast gauging. Sample SB-111 was collected over the entire watch period.

The following summarizes the ballast gauging performed by the 3/M.

Tank	Time	Duration (sec)
1C	2042:15	45
3C	2048:10	45
4C	2050:00	30
4C	2150:00	20
3C	2151:00	20
1C	2152:00	30
1C	2242:00	30
3C	2247:00	30
5C	2253:00	35
6C	2255:00	25

The 3/M spent the rest of the time during this shift away from these sources, usually by the rail upwind of the vapors.

Overtime Period 17A (0200-0400, Day 10)

The 3/M spent this entire overtime period in the wheehouse for maneuvering during undocking. Exposure monitoring was not performed.

Deck Watch Periods 18 (0800-1200, Day 10)
19 (2000-2400, Day 10)
20 (0800-1200, Day 11)
21 (2000-2400, Day 11)
22 (0800-1200, Day 12)

The deck watches for periods 18 through 22 were spent entirely in the wheelhouse navigating. No exposure monitoring was performed.

Overtime Period 18A (1300-1700, Day 10)

For this overtime period, the 3/M completed work on fire line maintenance replacing valve wrenches and relettering the pipes. Exposure monitoring was not justified.

Overtime Period 19A (0600-0800, Day 11)

Since the C/M was leading the tank cleaning efforts on deck, the 3/M reported for his normal watch two hours early. He was navigating in the wheelhouse for the entire period and monitoring was not performed.

Overtime Period 22A (1500-1600, Day 12)

The 3/M spent this entire overtime period in the wheelhouse for maneuvering during docking. Exposure monitoring was not justified.

IX. Summary of Activities and Occupational Exposures for Selected Crewman 8-12 A/B

The second crewman whose activities and occupational exposures were documented during the entire voyage was the A/B whose normal watch hours coincided with that of the 3/M (0800-1200 and 2000-2400). A chronological description of the regular work hours for A/B1 along with his overtime shifts are shown in Figure 3. The overtime shifts occurred only while the ship was in transit. At no time while the ship was docked for either loading or discharging of cargo did the selected A/B become involved in extended work activities.

A composite list of the A/B's activities during the entire voyage is shown in Table IV. Occupational exposure samples are also shown in the table and were collected during those activities in which higher than normal levels of contaminants were anticipated. On certain occasions, samples were also collected in the A/B's quarters to determine his exposure during off hours as a result of vapor infiltration.

The types of exposures sampled consisted of both cargo (gasoline) and non-cargo (paint) vapors as well as exposures to dust. The paint exposures are presented in Table V. The dust exposures were sampled during chipping of paint or sand blasting.

TABLE V. OCCUPATIONAL EXPOSURE TO PAINT VAPORS FOR SELECTED A/B (A/B1)

Sample No.	Exposure Duration (min)	Xylene (ppm)	Isobutanol (ppm)	Methyl Isobutyl Ketone (ppm)	Methyl Ethyl Ketone (ppm)
SB-97	34	10.44	4.10	ND	ND
SB-93	13	5.10	ND	ND	ND

In the remaining part of this section, a detailed discussion of the A/B's activities and occupational exposures noted in Table IV will be presented.

Deck Watch Period 1 (2000-2400, Day 1)

The responsibility of the A/B during this workshift was to assist the mate on watch (3/M) in periodic tank gauging. On most of the gauging rounds, the A/B's functions consisted of holding a flashlight and recording the ullage measurements that were being read by the 3/M. The A/B, however, did perform the actual ullage measurements on one of the gauging rounds during this period. Summarized below are the gauging rounds for which the 8-12 A/B was involved, with notation of the duration of time spent near each tank.

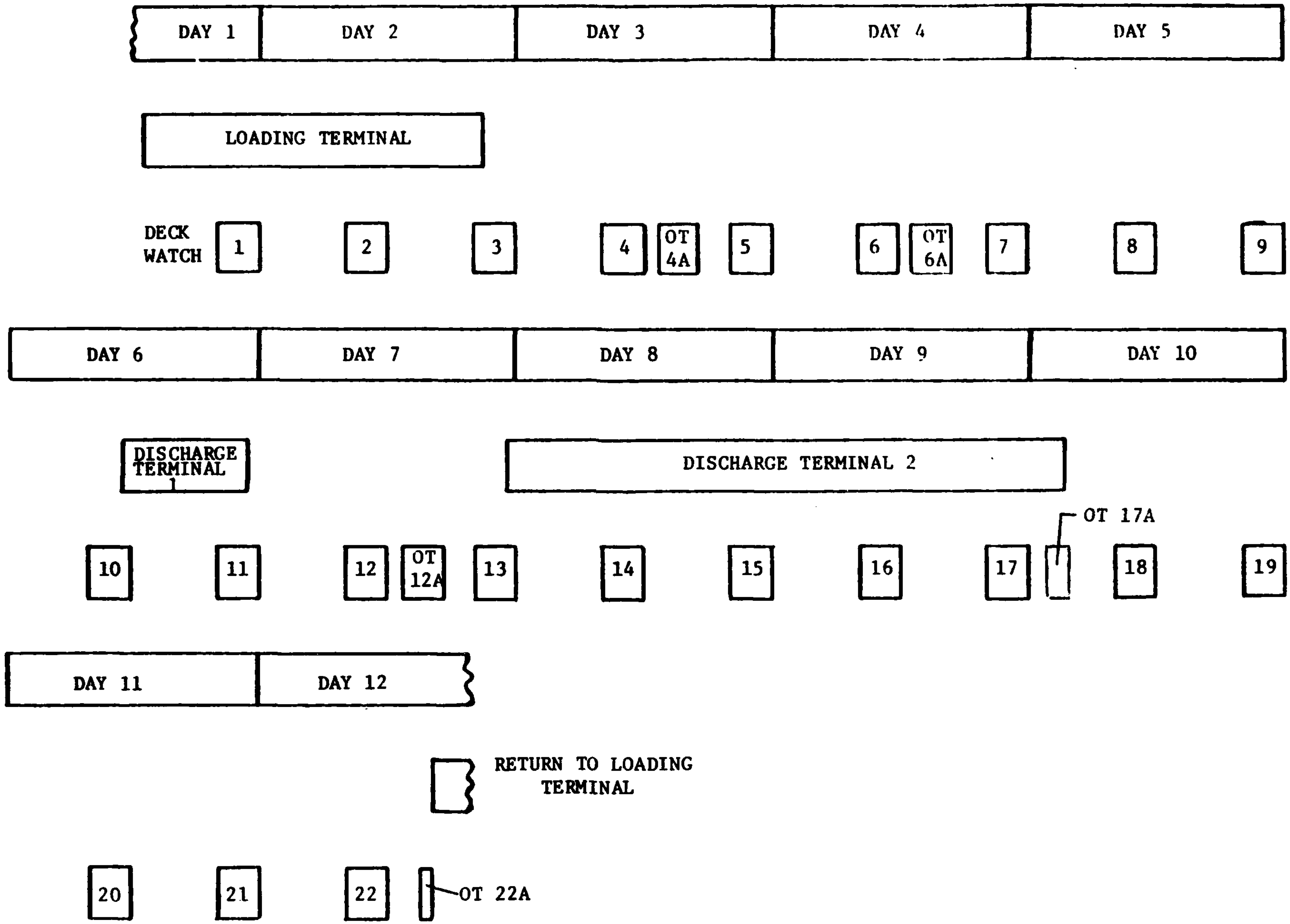

FIGURE 3. REGULAR AND OVERTIME WORK SHIFTS FOR A/B1

TABLE IV. SUMMARY OF ACTIVITIES AND EXPOSURES FOR A/BI

WORKER TITLE: A/B

WATCH: 0800 - 1200; 2000 - 2400

Voyage Day	Voyage Leg	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration ppm Benzene	Exposure Concentration ppm Gasoline	Exposure Duration (min)
1	Loading	Periodic Gauging	2000 - 2300	RT	SB-65	Gasoline Vapors	1.10	199.35	173
					63761	Gasoline Vapors	ND	221.12	173
		Periodic Gauging	2300 - 2400	RT	SB-69	Gasoline Vapors	5.70	907.47	43
					63763	Gasoline Vapors	5.91	1297.40	45
2	Loading	In Deckhouse	0000 - 0800	OFF	SB-66	Gasoline Infiltration	0.13	17.88	450
		Tank Top Off (General)	0800 - 1100	RT	SB-58	Gasoline Vapors	0.27	428.30	171
					63764	Gasoline Vapors	1.95	638.18	171
		Tank Top Off (General)	1100 - 1200	RT	SB-59	Gasoline Vapors	ND	46.86	50
		In Deckhouse	1200 - 2000	OFF	SB-52	Gasoline Infiltration	ND	3.06	471
		Undocking	2000 - 2130	RT	SB-85	Gasoline Vapors	1.73	19.9	80
		Wheelhouse Watch	2130 - 2400	RT	None	None	--	--	--
3	Laden No. 1	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1300	OFF					
		Chipping Paint	1300 - 1700	OT	None	None	--	--	--
		In Deckhouse	1700 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT					
4	Laden No. 1	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1300	OFF	None	None	--	--	--
		Chipping Paint	1300 - 1530	OT	SB-D-5	Dust (Paint & Rust)	Non Detectible		127
		Spray Painting	1530 - 1615	OT	SB-97	Paint Constituents	See Paint Exposure Table		34
		Spray Painting	1615 - 1700	OT	SB-93	Paint Constituents	See Paint Exposure Table		13

TABLE IV. SUMMARY OF ACTIVITIES AND EXPOSURES FOR A/B1 (CONTD)

WORKER TITLE: A/B

WATCH: 0800 - 1200; 2000 - 2400

Voyage Day	Voyage Leg	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration ppm Benzene	ppm Gasoline	Exposure Duration (min)
4 (cont'd)	Laden No. 1	In Deckhouse	1700 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
5	Laden No. 1	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
6	Disch. No. 1	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1000	RT	None	None	--	--	--
		Hose - Connect	1000 - 1200	RT	SB-63	Gasoline Vapors	ND	4.72	29
		In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
		Undocking	2000 - 2300	RT	None	None	--	--	--
		Wheelhouse Watch	2300 - 2400	RT	None	None	--	--	--
7	Laden No. 2 & Disch. No. 2	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1300	OFF	None	None	--	--	--
		Chipping Paint	1300 - 1700	OT	SB-D-16	Dust (Paint & Rust)	Non-Detectible		93
			1700 - 2000	OFF					
		Wheelhouse Watch	2000 - 2300	RT	None	None	--	--	--
		Hose Connect	2300 - 2400	RT	SB-10	Gasoline Vapors	1.55	96.78	42
8	Disch. No. 2	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Periodic Gauging	0800 - 1200	RT	SB-90	Gasoline Vapors	ND	3.52	215
		In Deckhouse	1200 - 2000	OFF	SB-108	Gasoline Infiltration	0.11	1.37	464
		Periodic Gauging	2000 - 2400	RT	SB-99	Gasoline Vapors	ND	2.21	60

TABLE IV. SUMMARY OF ACTIVITIES AND EXPOSURES FOR A/BI (CONTD)

WORKER TITLE: A/B

WATCH: 0800 - 1200; 2000 - 2400

Voyage Day	Voyage Leg	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration		Exposure Duration (min)
							ppm Benzene	ppm Gasoline	
9	Disch. No. 2	In Deckhouse	0000 - 0800	OFF	SB-100	Gasoline Infiltration	ND	ND	430
		Periodic Gauging	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
		Periodic Gauging	2000 - 2400	RT	SB-53	Gasoline Vapors	0.25	40.98	225
		Hose Disconnect		RT	SB-22	Gasoline Vapors	ND	34.45	67
10	Disch. No. 2 & Ballast	In Deckhouse	0000 - 0200	OFF	None	None	--	--	--
		All Hands	0200 - 0400	OT	None	None	--	--	--
		In Deckhouse	0400 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
11	Ballast	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 2000	OFF	None	None	--	--	--
		Wheelhouse Watch	2000 - 2400	RT	None	None	--	--	--
12	Ballast	In Deckhouse	0000 - 0800	OFF	None	None	--	--	--
		Wheelhouse Watch	0800 - 1200	RT	None	None	--	--	--
		In Deckhouse	1200 - 1500	OFF	None	None	--	--	--
		All Hands	1500 - 1600	OT	None	None	--	--	--

Start of Gauging Round	Tank	Duration (sec)
2200	6S	25 F*
	6C	30 F
	6P	20 F
	3P	20 F
	3C	15 F
	3S	20F
2231	4S	60
	4C	60
	4P	52
	5S	30
	5C	90
	5P	30
2333	5S	15 F
	5C	25 F
	5P	20 F
	4P	25 F
	4C	35 F
	4S	30 F
	2S	25 F
	1S	27 F

The majority of the time he was 1 - 1.5 feet upwind or crosswind of the gauging standpipe. During the 2231 gauging round, he stood closer to the standpipe than before in order to read an accurate ullage.

When the A/B was not making gauging rounds, his activities were somewhat random and consisted of:

- o checking tension of the mooring lines,
- o being on standby upwind of the expansion trunk of the last tank gauged during a particular gauging round,
- o being on standby upwind of the loading manifold, and
- o being on break in deckhouse for approximately 20 minutes each on two occasions.

Two sets of sequential occupational exposure samples were collected during this 4-hour watch with both active (pump and tube) and passive dosimeters. The time periods corresponding to the samples are noted below.

F* indicates that A/B held flashlight for 3/M who took actual ullages

Time	Activity	Sample Number
2200-2300	Periodic Gauging	SB-65 * 63761 **
2300-2400	Periodic Gauging	SB-69 63763

Deck Watch Period 2 (0800-1200, Day 2)

The primary activities occurring during watch No. 2 consisted of the topoff of 6 of the ships 18 cargo tanks and one periodic gauging round of tanks 3P, 3C, and 3S. The A/B's work activities, as noted previously, were again one of assistance to the 3/M. A/B1 did not topoff any of the tanks. Instead, his normal duty was to be in closed proximity of the particular tank being topped off waiting for orders from the 3/M to close down on the product valve to that tank. These locations varied from sitting on the ship's center pipeway, when a center tank was being topped off, to actually manning the tank's product valve. These were usually areas that were either upwind or crosswind of the particular tank being topped off but still downwind of other tanks not yet finished loading.

When not directly assisting the 3/M on tank topoff, A/B1 either made several rounds of the ship's deck checking on mooring lines, was on break (total of two, 20 minutes each), or sat near the starboard loading manifold.

Two sets of sequential exposure samples were taken during this watch as noted below.

Time	Activity	Sample Number
0759-1050	Tank Topoff	SB-58 63764
1100-1150	Tank Topoff	SB-59

Deck Watch Period No. 3 (2000-2400, Day 2)

Since all loading had finished on the previous watch period (1600-2000 watch), the major activities performed by A/B1 were concerned with preparing the ship for sailing. Some of the tasks that the A/B was involved in were:

o storing of safety equipment and gear,

o being on standby near the half full loading manifold drip tray waiting for shore analysis of final ullage samples, and

o retrieval of the mooring line during undocking.

---

* active charcoal sample
** typical five digit number indicates passive charcoal sample badges

These tasks lasted for approximately 40% of his third watch period. The remaining portion was spent in the wheel house on navigation duty.

The A/B's occupational exposure was monitored only during the initial part of the watch and was collected on sample SB-85.

Deck Watch Periods 4 (0800-1200, Day 3), 5 (2000-2400, Day 3), 6 (0800-1200, Day 4), 7 (2000-2400, Day 4), 8 (0800-1200, Day 5), 9 (2000-2400, Day 5).

While the ship was in transit, A/B1 usually spent his watch period in the wheel house navigating the ship at the direction of the 3/M. In fact, during his 4-hour night shift (2000-2400 hrs), he did not leave the wheel house. During the day shift (0800-1200), however, he occasionally left the wheel house to perform various housekeeping chores such as washing down both the deck outside the wheel house and the boat deck, which was just below the wheel house. He was allowed to do these activities during the day watch provided the ship was far enough away from shore and other ship traffic was low.

OVA surveys of the wheel house and those areas that the A/B worked outside of the wheel house indicated normal hydrocarbon background concentrations of ambient air, 5 ppm as methane. Consequently, exposure samples were not collected during these six watch periods.

Overtime Periods 4A (1300-1700, Day 3), 6A (1300-1700, Day 4)

During the off-watch day hours of the laden voyage, A/B1 performed ship maintenance activities, including paint and rust chipping, brush painting, and spray painting.

A/B1's major activities during period 4A were paint and rust chipping and brush painting with primer. Because occupational exposure monitoring was already being conducted on other crewmen performing similar activities, A/B1 was not monitored. See Chapter X for these similar exposures.

A/B1's major activities during period 6A were paint and rust chipping and spray painting. A summary of the exposure samples collected is presented below.

Time	Activity	Sample Number
1300-1530	Paint and Rust Chipping	SB-D-5
1530-1615	Spray Painting	SB-97
1615-1700	Spray Painting	SB-93

All of the mixing of the two-part paint was done by hand in small cans. This A/B stood downwind of the paint he was mixing, and his breathing zone was approximately 2 feet from the paint can. This mixing lasted from 1024-1035.

The first item he painted was the port stern deckhouse entry door. Because of its location on the back of the deckhouse, there was recirculation of the paint mist in the area. Paint vapors infiltrated into the deckhouse hallway. The total time to paint the door was 3 minutes.

Next, the A/B painted the port stern railing and port starboard bits. He normally stood upwind or crosswind of the objects being painted, and because they were in open areas, the excess spray was rapidly blown away.

Spray Painting-O/S (1132-1140, Day 5)

The activity during this work period consisted of spray painting the surfaces that were sandblasted during the 0844-1115 work period of day 5. The overall activity lasted a short time. Sample SB-56 was collected on the O/S during this time period.

Gauging Round with the Q.C. Inspector-C/M (1020-1045, Day 6)

During this time period, the C/M went on a gauging round with a quality control inspector who took ullage measurements on each tank. Exposure sample SB-77 was collected on the C/M during this entire period.

A summary of the gauging times is given below.

Tank	Time	Duration (sec)	Gauging Location DW (Downwind) UW (Upwind) CW (Crosswind)
3S	1030:00	20	DW
3C	1030:30	20	UW
2S	1031:10	15	UW
2C	1031:35	15	UW
1S	1032:00	27	UW
1C	1032:40	45	UW
1P	1033:44	41	DW
2P	1034:54	35	DW
3P	1035:50	31	CW
4P	1036:50	44	DW
5P	1037:54	30	DW
6P	1038:37	23	CW
6C	1039:20	20	DW
6S	1039:57	21	DW
5S	1040:32	28	CW
5C	1041:10	25	CW
4S	1041:51	24	UW
4C	1042:25	25	UW

Sandblasting-O/S (0844-0955, 1053-1115, Day 5)

During these two periods, an O/S sandblasted those deck surfaces that had undergone rust chipping the day before. A portion of the time was spent sandblasting near the wall of the deckhouse on the ship's stern. The other surfaces that were sandblasted included the mooring line guide and a bit. One cumulative dust sample (SB-D-12) was collected during this activity. Sampling was stopped from 0955-1053 during the crew member's work break.

While he was sandblasting, the O/S wore a hood that draped over his head and down to the middle of his chest. While the hood protected his eyes from the flying sand, its loose fit at the bottom, allowed the fine sand from the visible dust cloud to enter underneath the hood. To counteract this, the O/S also wore a filter mask over his nose and mouth. However, the filter* was approved for organic vapor instead of dust.

He normally sat upon a milk crate while he was sandblasting the deck surfaces. Because the dust cloud was so concentrated, he also had to bend over to see what he was doing. His posture caused the front lower portion of the hood to lean away from his chest and allowed the dust cloud to enter the breathing zone.

The dust sampler was attached to the O/S's lapel underneath the hood.

Rust Chipping-A/B (0900-0935), Day 5)

During this time period, an A/B chipped rust with a needle gun on the port stern deck and rail downwind of sandblasting activities. For the entire time he wore headphone type ear protection and sunglasses. Because he was sometimes working outside the railing, he also wore a life jacket and belt harness. Dust exposure sample SB-D-7 was collected from 0900-0935 on this A/B.

Most of the time he chipped from downwind, in order to see his work, approximately 2 feet from his face.

Spray Painting-A/B (1020-1125, Day 5)

During this time period, an A/B mixed paint, cleaned sand off the areas to be painted, and painted the stern port entry door, stern bits, and railing. For this entire time he wore sunglasses and cloth work gloves. Exposure sample SB-81 was collected from 1024-1125 on this A/B.

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* Pulmosan Safety Equipment Filter No. TC-236-81.

Time	Activity	Sample No.
0845 - 1015	Rust Chipping	SB-D-6
1100 - 1200	Rust Chipping	SB-D-18

He chipped steadily from 0836 - 1000 and 1100 - 1200. Most of the time, he chipped from crosswind or upwind approximately $1\frac{1}{2} - 2\frac{1}{2}$ feet from his face. Sometimes it was necessary for him to be downwind of the chipping in order for him to see his work.

*Run-around Changeover-O/S (0825-0922, 0923-0954, Day 4)

During this time period, two run-arounds were transferred from the port loading manifold to the starboard manifold. Two sequential exposure samples were collected on one of the two individuals involved in this activity. The first sample, SB-88, was obtained from 0825-0922 during run-around removal from the loading manifold on the port side. The second sample, SB-95, was collected while the run-around was being bolted onto the starboard manifold (0923-0954).

The O/S's activity on the port side consisted of unbolting the two flanged connections between the run-around and the mating flanges of the manifold valves. Prior to loosening the bolts, small drain valves were opened to drain the product in the run-around into the drip pan. When the first bolts were loosened, more product spilled out. Since the drip tray was approximately half-full, the O/S connected a drain hose to the drip tray and discharged its contents overboard.

Once the run-around was detached, blind flanges were bolted onto the open manifold valve flanges, and the run-around removal was completed.

The distance from the O/S's breathing zone to the source of gasoline vapors varied from 2 - 6 feet during most of the activity. Most of his work was performed while he was standing on the deck leaning over the drip tray. The top of the drip tray was approximately 3.5 feet above the deck. At times, he would get on top of the pan grating and assume either a squatting or standing position.

The overall activity conducted on the starboard side in attaching the run-around was very similar except it was performed in the reverse order.

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* A run-around is a U-shaped section of piping used to allow:

1. product loading through one hose from shore into two series of ship tanks, or
2. product discharge from two series of ship tanks through one hose to the shore.

When not gauging, the C/M stood upwind or crosswind of the deck riser with his breathing zone approximately 5 feet from the riser opening.

Spray Painting-O/S (1023-1150, 1300-2400, Day 3)

During these two work periods, an O/S mixed paint in the forecastle and spray painted the stern port and starboard engine room machinery hatches. One occupational exposure sample, SB-84, was collected for both work periods. During the 1150 and 1300 lunch break, the sampling pump was turned off. The following summarizes the O/S's activities during this observation period.

1. Approximately 30 minutes of his time was spent mixing the two-component paint in the forecastle.

2. The total time that he spent spray painting was 43 minutes. Most of the time he stood upwind or crosswind of his work, but sometimes he stood downwind in order to see the area he was spraying.

3. The remainder of the sampling time was spent:

   - in transit between the paint mixing area and the stern, or

   - cleaning equipment.

Rust Chipping-O/S (1410-1455, Day 3)

During this period, the O/S chipped rust from the port mooring line guide with a pneumatic impacting tool. He started the chipping without any dust protective equipment, but after approximately eight minutes, he went forward and returned with a surgical type dust mask and gloves. He resumed the activity and spent the remaining portion of the period chipping rust from the same deck fixture.

He was normally in a prone position while performing this activity. His breathing zone distance from the object was approximately 1 - 2-1/2 feet.

One dust sample was collected, SB-D-13, on the O/S to determine his exposure to airborne particulate.

Rust Chipping-A/B (0800-1200, Day 4)

During this time period, an A/B chipped rust on the starboard stern deck using an air powered needle gun. For the entire time he wore goggles and headphone type ear protection, but no respiratory protection. The following dust exposure samples were taken during this time period.

TABLE VII. OCCUPATIONAL EXPOSURES TO PAINT VAPOR FOR VARIOUS CREWMEN

Sample No.	Exposure Duration (min)	Xylene (ppm)	Isobutanol (ppm)	Methyl Isobutyl Ketone (ppm)	Methyl Ethyl Ketone (ppm)
SB-84	142	5.04	1.82	ND	ND
SB-56	8	9.68	ND	ND	ND
SB-55	141	3.16	1.20	--	--
SB-61	68	1.89	3.25	--	--
SB-201	130	6.78	3.25	--	--
SB-81	61	5.92	3.01	--	--

TABLE VI. SUMMARY OF ACTIVITIES AND EXPOSURES MONITORED FOR VARIOUS CREWMEN (CONTD)

WORKER TITLE: Various Crewmen

WATCH: As noted

Voyage Day	Voyage Leg	Worker Title	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration ppm Benzene	Exposure Concentration ppm Gasoline	Exposure Duration (min)
11	Ballast	A/B	Tank Washing & Blowing	0600 - 1200	OT 0600 - 0800 RT 0800 - 1200	SB-117	Gasoline Vapors	0.73	146.83	354
		A/B	Tank Washing & Blowing	0600 - 1200		60389	Gasoline Vapors	0.71	223.06	354
		O/S	Tank Washing & Blowing	0600 - 1200	OT 0600 - 0800 RT 0800 - 1200	SB-119	Gasoline Vapors	0.66	143.15	333
		O/S	Tank Washing & Blowing	0600 - 1200		60390	Gasoline Vapors	ND	197.33	333
		O/S	Tank Washing & Blowing	1200 - 1710	RT	SB-110	Gasoline Vapors	0.34	63.54	309
		O/S	Tank Washing & Blowing	1200 - 1710	RT	60391	Gasoline Vapors	0.97	55.99	309
		A/B	Tank Washing & Blowing	1250 - 1710	RT	SB-205	Gasoline Vapors	0.64	63.33	261
		A/B	Tank Washing & Blowing	1250 - 1710	RT	60392	Gasoline Vapors	ND	86.31	261
11	Ballast	O/S	Tank Cleaning	0600 - 1200	OT 0600 - 0800 RT 0800 - 1200	SB-209 63766	Gasoline Vapors Gasoline Vapors	0.21 ND	42.40 55.95	341 296
	Ballast	C/M	Tank Cleaning	0600 - 1200	OT 0600 - 0800 RT 0800 - 1200	SB-103 63765	Gasoline Vapors Gasoline Vapors	2.08 0.90	201.50 241.68	344 309
11	Ballast	O/S	Tank Cleaning	1215 - 1700	OT 1215 - 1300 RT 1300 - 1700	SB-207 63775	Gasoline Vapors Gasoline Vapors	0.48 ND	83.58 64.06	285 265
		C/M	Tank Cleaning	1241 - 1405	RT	63777	Gasoline Vapors	6.10	409.44	84

TABLE VI. SUMMARY OF ACTIVITIES AND EXPOSURES MONITORED FOR VARIOUS CREWMEN (CONT'D)

WORKER TITLE: Various Crewmen

WATCH: As noted

Voyage Day	Voyage Leg	Worker Title	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration ppm Benzene	Exposure Concentration ppm Gasoline	Exposure Duration (min)
7	Laden No. 2	O/S	Spray Painting	0927 - 1148	RT	SB-55	Paint Constituents &	See Paint Exposure Table		141
							Gasoline Vapors	ND	9.48	141
		O/S	Spray Painting	1329 - 1437	RT	SB-61	Paint Constituents &	See Paint Exposure Table		68
							Gasoline Vapors	0.75	156.51	68
7	Laden No. 2	O/S	Spray Painting	1440 - 1650	RT	SB-201	Paint Constituents &	See Paint Exposure Table		130
							Gasoline Vapors	ND	2.34	130
7	Laden No. 2	O/S	Changing Run-around	1740 - 1825	OT	SB-120	Gasoline Vapors	6.42	501.30	41
		O/S	Run-around Changeover	1742 - 1820	OT	SB-104	Gasoline Vapors	2.7	315.99	38
		A/B	Hose Connect	2310 - 2350	OT	SB-83	Gasoline Vapors	ND	21.48	42
8	Disch. No. 2	2/M	Stripping 6P	1200 - 1230	RT	SB-80	Gasoline Vapors	7.00	166.91	21
		2/M	Stripping 6C	1230 - 1315	RT	SB-79	Gasoline Vapors	ND	147.51	45
8	Disch. No. 2	C/M	Stripping 1C	1607 - 1630	RT	SB-114	Gasoline Vapors	ND	135.6	23
		--	Area Sample (1)	1612 - 1631	--	SB-76	Gasoline Vapors	4.5	610.78	19
		C/M	Stripping 1S	1634 - 1649	RT	SB-107	Gasoline Vapors	ND	ND	15
		--	Area Sample (2)	1635 - 1650	--	SB-74	Gasoline Vapors	ND	ND	15
9	Disch. No. 2	O/S	Hose Disconnect	2225 - 2341	RT	SB-202	Gasoline Vapors	0.38	22.06	76
10	Ballast	A/B	Sandblasting	1035 - 1115	RT	SB-D-19	Sand	6.73 mg/m³	(Quartz)	40

(1) Taken at Butterworth opening of 1C where tank gaugings were made during stripping.
(2) Taken at Butterworth opening of 1S where tank gaugings were made during stripping.

TABLE VI. SUMMARY OF ACTIVITIES AND EXPOSURES MONITORED FOR VARIOUS CREWMEN

WORKER TITLE: Various Crewmen

WATCH: As noted

Voyage Day	Voyage Leg	Worker Title	Worker Activities	Time of Observation	Regular Time (RT) Overtime (OT) or OFF	Sample Number	Exposure	Exposure Concentration		Exposure Duration (min)
								ppm Benzene	ppm Gasoline	
2	Loading	C/M C/M	Tank Topoff 1P,1S,1C	0525 - 0620	RT	SB-67 60384	Gasoline Vapors " "	16.47 29.50	2661.9 5135.0	52 52
3	Laden No. 1	O/S	Spray Painting	1000 - 1200 1300 - 1400	RT RT	SB-84	Paint Constituents	See Paint Exposure Table		142
		O/S	Rust Chipping	1400 - 1500	RT	SB-D-13	Rust Dust	Non-Detectible		45
4	Laden No. 1	A/B A/B	Rust Chipping Rust Chipping	0845 - 1015 1100 - 1200	OT OT	SB-D-6 SB-D-18	Rust Dust Rust Dust	Non-Detectible Non-Detectible		84 56
4	Laden No. 1	O/S	Run-around Changeover: Port Side Removal Stbd Side Connect	 0825 - 0922 0923 - 0954	 RT RT	 SB-88 SB-95	 Gasoline Vapors Gasoline Vapors	 ND ND	 34.62 ND	 57 31
5	Laden No. 1	O/S	Sandblasting	0844 - 0955 1053 - 1115	RT RT	SB-D-12	Sand	7.37 mg/m³	(Quartz)	94
5	Laden No. 1	A/B	Rust Chipping	0900 - 0935	OT	SB-D-7	Rust Dust, Sandblasting	Non-Detectible		28
		A/B	Spray Painting	1020 - 1125	OT	SB-81	Paint & Thinner Vapors	See Paint Exposure Table		61
			Spray Painting	1132 - 1140	RT	SB-56	Paint Constituents	See Paint Exposure Table		8
6	Disch. No. 1	C/M 2/M	Gauging Round with Q.C. Stripping 2C	1020 - 1045 1530 - 1600	OT OT	SB-77 SB-82	Gasoline Vapors Gasoline Vapors	ND ND	73.26 ND	25 31
	Disch. No. 1	A/B	Hose Disconnect	1630 - 1710	RT	SB-46	Gasoline Vapors	ND	5.97	40
		C/M	Ballasting Gauging 2C	1645 - 1800	OT	SB-101	Gasoline Vapors	ND	ND	76

X. Summary of Monitored Activities and Occupational Exposure for Various Deck Department Personnel

The following is a detailed discussion of the activities and occupational exposures for workers other than the 3/M and the designated A/B. These observations were conducted in order to document a more complete set of work activity scenarios that occurred during this voyage, some of which never involved the 3/M or A/B1.

Table VI summarizes the activities for workers other than the 3/M or A/B1. Table VII presents the occupational exposures to paint vapors for these workers.

Tank Topoff - C/M (0500-0630, Day 2)

During this time period, the C/M topped off tanks 1P, 1S, and 1C. Due to the short duration of each topoff, only one set of samples, SB-87 and 60384, was taken to encompass all three topoffs.

The topoff of 1P was very short and lasted only 5 minutes (0525-0530). The C/M used a crucifix to take continual readings while standing crosswind of the hatch or gauging tube.

The entire topoff of 1S lasted approximately 20 minutes (0530-0550). The time between 0430 and 0544 was spent waiting for the liquid to reach the bottom of the crucifix. The topoff gauging with the crucifix then lasted six minutes (0544-0550). During this time, continual readings were taken from crosswind of the deck riser.

The topoff of 1C took considerably longer than 1P or 1S mainly because the tank was short-loaded and had to be gauged using a tape. The following summarizes the ullages taken during the topoff of 1C.

Encounter No.	Time	Duration (sec)
1	0555:40	10
2	0558:30	4
3	0559:28	7
4	0601:45	7
5	0603:15	5
6	0603:34	6
7	0604:45	6
8	0605:00	2
9	0606:00	3
10	0606:57	2
11	0607:24	2
12	0608:20	4
13	0610:35	3
14	0610:40	10
15	0615:50	8
16	0616:52	14
	0617:10	Stopped 1C

Deck Watch Periods 18 (0800-1200, Day 10)
19 (2000-2400, Day 10)
20 (0800-1200, Day 11)
21 (2000-2400, Day 11)
22 (0800-1200, Day 12)

During these five regular watch periods, the A/B performed typical wheelhouse navigation duties and exterior house cleaning chores, similar to those described for watches 4 through 9. Exposure monitoring was not performed.

Overtime Period 22A (1500-1600, Day 12)

During this overtime period, A/B1 was in the wheelhouse for maneuvering activities while docking. Exposure monitoring was not performed.

Two occupational exposure samples were collected on the A/B during this watch. One of the samples was a full watch sample, while the other was collected concurrently with the shorter duration hose disconnect activity. The sample numbers and sampling periods are presented below.

Time	Activity	Sample Number
2002-2347	Complete Watch	SB-53
2225-2347	Hose Disconnect	SB-22

The first hour of the A/B's watch was spent cleaning up the wheel house. Following this task, he came back out onto the deck to assist the 3/M. Although tanks were being ballasted, the A/B did not gauge any of the tanks. Instead, he spent most of his time at the fore and aft tie line winches taking the slack out of the mooring lines.

A/B1 and one other crewman disconnected the discharge hoses. The normal procedure for each hose was as follows:

- o The valve on the ship's manifold was opened to drain the residual product from the line into the drip pan.
- o The loading hose was secured to the ship's boom.
- o One or both crewmen unfastened all but one of the bolts connecting the ship's flange to the loading hose flange.
- o The boom was activated to raise or lower the hose to free the last bolt.
- o A blind was attached to the hose flange and the hose was lowered to the dock.
- o A blind was bolted to the ship's valve flange.

Four hoses in all were disconnected with each hose removal requiring about 8-10 minutes each. A substantial amount of liquid was released into the drip pan during the line draining step. The A/B's distance from the drip pan varied from two feet when he was bolting the blind to the ship's flange to approximately eight feet when he was near the railing guiding the hose onto the dock.

Overtime Period 17A (0200-0400, Day 10)

During this overtime period, the A/B assisted in undocking activities. Since all hatches had been secured, the potential for exposure was minimal, and no exposure samples were collected.

The A/B made two gauging rounds during this watch. On some of the tanks he had trouble determining the ullage, and stuck his face against the open gauging standpipe to visually check the cargo level. The tanks that the A/B gauged during these two rounds along with the gauging durations are shown below.

Tank	Time	Duration (sec)
1P	1008:20	30
1C	1009:10	420
1S	1016:20	80
1C	1017:50	20
5C	11:09:25	15
5S	11:09:48	12
6P	11:22:10	40

The remaining portion of his time was spent sitting on the center deck piping or port side railing or in the deckhouse on break (twice, 20 minutes each).

One personal sample (SB-90) was collected on the A/B during this watch to monitor his exposure to gasoline vapor.

Deck Watch Periods 15 (2000-2400, Day 8)
16 (0800-1200, Day 9)

Heavy rains occurred during both of these watch periods and altered the work activities of the A/B as compared to the tasks he performed during his previous watch. The A/B spent most of his time inside one of the six pump houses. Although tanks were being gauged, the 3/M was the only one performing this activity. The A/B periodically checked the status of the bow and stern mooring lines.

Exposure sample SB-99 was collected on A/B1 during the first hour of watch period 15. His exposure was not monitored during watch period 16.

Deck Watch Period 17 (2000-2400, Day 9)

Product discharge was completed during the previous watch period (1600-2000). Therefore, the A/B's major activities consisted of assisting the 3/M in ballast gauging, housekeeping chores in the wheel house, and assisting in hose disconnect.

Overtime Period No. 12A (1300-1700, Day 7)

During this period, the A/B performed paint and rust chipping activities on the starboard railing near midship. Since this activity generated dust, an exposure sample was collected. The exposure sample was SB-D-16.

Deck Watch Period 13 (2000-2400, Day 7)

A/B1's activities during this watch period were similar to watch period No. 10 and involved a combination of wheel house navigation duty, docking and hose hookup at discharge terminal No. 2. The procedures that were used to connect the hoses were described earlier. On this occasion, however, A/B1 was the person who was standing on top of the drip pan while unbolting the product piping flanges. Some product drained from the ship's product piping into the drip pan when flanges were removed. A total of three hoses were connected.

As compared to the hose hookup activities that were performed in watch period No. 10, the A/B was in closer proximity to the gasoline vapors emitting from the drip pan and was there for a longer period of time. His exposure during this hose hookup was collected on Sample SB-10.

Deck Watch Period 14 (0800-1200, Day 8)

During this watch period, all of the remaining product was being discharged to shore. Initially, most of the tanks were still quite full. Activities performed by the A/B consisted of deck cleaning, manning product valves during the stripping of tanks 2P and 2S, and periodic gauging.

The deck cleaning activity resulted from a slight leak at the check valve on pump 4. Although the leak was repaired immediately, a portion of the deck near the check valve still contained liquid cargo. The A/B spent the first hour of his watch cleaning up the deck spill by spreading adsorbent over it and then sweeping it up.

Following the deck cleanup operation, A/B1 assisted the 3/M in the stripping of tanks 2S and 2P. His main activity was to man the product valves and stand ready for orders from the 3/M to close them.

Deck Watch Period No. 10 (0800-1200, Day 6)

The A/B's activities during this watch period were split between wheel house watch duties and deck work involving docking and subsequent hose hookup at the first discharge terminal. During the initial stages of docking, he was involved in handling the ship's mooring lines. After the ship was secured to the dock, he along with five other unlicensed crewmen connected the discharge hoses to the ship's loading/discharge manifold product piping. A total of three hoses were connected to the ship at this terminal.

The sequence of steps that were followed to connect each loading hose to the ship are summarized below:

- One of the crewmen sat or stood on the manifold drip pan and removed the product piping blind.

- A shore winch raised the discharge hose onto the ship's deck.

- The other crewmen, standing on deck, then aligned the hose flange with the ship flange and bolted them together.

The time spent connecting each hose was approximately 6 to 7 minutes. During the hose connecting activity, the A/B stood crosswind of the drip pan and helped to align the hose and ship flanges. On occasion, he got on top of the drip pan to assist in attaching the bolts. Since there was a potential for exposure from cargo liquid in the drip pan, a personal sample (SB-63) was collected on A/B1 during the hose connection activity.

The remaining part of his watch was spent either in the deck house on break or checking the mooring lines.

Deck Watch Period 11 (2000-2400, Day 6)

Prior to the start of this watch period, product discharge had been completed, and all hoses had been disconnected. Consequently, the A/B's watch consisted of undocking activities and wheel house navigation duty. Due to the low levels of hydrocarbons on the deck where the A/B was located, no exposure samples were collected.

Deck Watch Period 12 (0800-1200, Day 7)

Because the ship was underway enroute to the second discharge port, the A/B was in or near the wheel house on navigation watch. His activities during this period were similar to those discussed for watch periods No. 4 through No. 9 and did not warrant exposure monitoring.

Discharge Stripping-2/M (1530-1602, Day 6)

During this time period, the 2/M stripped the product from tank 2C. Exposure sample SB-82 was collected on the 2/M during this activity.

For the time period 1530-1544, the 2/M was waiting for the product level to drop to the point where he needed to slow the pump and/or close valves. During this time he checked the product level three times as summarized below.

Encounter No.	Time	Duration (sec)
1	1535	60
2	1538	20
3	1542	10

These checks were performed by kneeling or leaning over a Butterworth opening with the breathing zone immersed in the opening.

Between 1544 and 1557, the 2/M knelt next to the opening, watched the product, and instructed the A/B and O/S to close valves. At 1557, the stripping was stopped.

After looking into the tank for approximately one additional minute, the 2/M decided to strip more product out of the tank. The tank was finally stripped from 1558 to 1600.

Hose Disconnect-A/B (1630-1710, Day 6)

During this time period, the A/B attached the sling from the shore side boom to the three discharge hoses. Exposure sample SB-46 was collected on the A/B during this time period.

The A/B's main function was to connect the sling from the shore side boom to the discharge hose and then direct the dock personnel on the maneuvering of the hose. This maneuvering enabled the other crewmen to disconnect the hoses at the ship's manifold. Since he had to be in sight of the dock personnel, this A/B stood by the ship railing approximately six feet from the manifold drip tray.

Ballast Gauging-C/M (1644-1800, Day 6)

During this time period, tank 2C was ballasted to an ullage of 40 feet. Exposure sample SB-101 was collected on the C/M during this entire period.

Since this was the only tank being ballasted and the ship was almost totally full, no ullage readings were taken. Instead, the C/M used the ship's load computer to determine when ballasting should terminate. Actually, the C/M spent only a few minutes by tank 2C. The rest of the time he was either in the deckhouse, which was upwind, or walking around the deck upwind of 2C.

Spray Painting-O/S (0927-1148, Day 7)
(1329-1437, Day 7)
(1440-1650, Day 7)

Extensive spray painting was performed by this O/S during the entire day work shift. His task was to spray paint all 18 of the ship's expansion trunks, hatches and product valve stems. In addition to a potential exposure to paint vapors, the O/S also was in the vicinity of gasoline vapors vented through P/V valves from partially filled or empty tanks. Three personal samples were collected on the O/S to monitor his exposure to both paint and gasoline vapors. The sample numbers and corresponding sampling periods are listed below.

Time	Sample Number
0927 - 1148	SB-55
1329 - 1437	SB-61
1440 - 1650	SA-201

The spray painting activities on Day 7 are summarized on the following page.

Time	Activity
0927 - 0951	mixing paint in forecastle and preparing spray paint equipment
0951 - 1025	break
1025 - 1045	connecting spray gun air line to on deck compressed air source
1048 - 1112	spray painting fixtures
1112 - 1120	moving spray gun air lines to on deck air source close to No. 2 tanks
1120 - 1148	spray painting No. 2 across tank fixtures
1329 - 1346	air drying No. 3 across tanks
1346 - 1402	spray painting No. 3 across tank fixtures
1402 - 1409	mixing paint
1409 - 1436	spray painting No. 3 across tank fixtures
1426 - 1437	mixing paint and moving spray gun air line to vicinity of No. 4 tanks
1440 - 1500	spray painting No. 4 across tank fixtures
1500 - 1530	break
1530 - 1534	mixing paint
1534 - 1540	spray painting No. 4 across tank fixtures
1540 - 1547	spray painting No. 5 across tank fixtures
1547 - 1602	mixing paint
1602 - 1616	spray painting No. 5 tank fixtures
1616 - 1620	mixing paint
1620 - 1630	moving spray gun airline to vicinity of No. 6 tanks
1630 - 1654	spray painting No. 6 across tank fixtures

Changing Run-around-O/S (1740-1825, Day 7)

During this time period, two ordinary seamen (O/S) changed a run-around from the port to the starboard manifold. Exposure samples were collected on both O/S's as noted below.

O/S No.	Sample
1	SB-120
2	SB-104

O/S1 first opened the small drain valves on the manifold pipes that were connected to the run-around. While the product was draining into the drip pan, O/S1 stood back against the rail approximately 10 feet upwind. When the product flow had reduced to a trickle, he loosened the bolts of the flanges and dropped the run-around onto the grate in the drip pan. When the flanges were loosened, more product poured out of the piping. This sequence lasted from 1740 to 1754.

After bolting the blanks on the pipe flanges on the port side, O/S1 carried the run-around to the starboard side. When the starboard flange on pipe 6 was loosened, once again liquid poured into the drip pan. Because of the placement of the drip tray, the O/S was standing directly downwind at this point. Product poured into the drip pan for two minutes (1800-1802).

The run-around was then bolted into place with O/S1 standing on the grate in the drip tray. General cleanup of the bolts laying in the two drip trays and removal of the starboard blank for pipe 5 occupied O/S1's time to the end of this period.

The activities of O/S2 were similar to O/S1. While O/S1 handled the unbolting of the run-around and blanking off of the manifold valve flange, O/S2 was performing the same tasks on the other end of the run-around. His (O/S2) position relative to the drip tray varied as did O/S1 from leaning against the tray during removal of run-around to near the ship's railing while the product piping was drained.

One major difference between this run-around changeover and the one conducted during Day 4 was that in this case, the drip tray was not drained. Whatever product was drained from the product piping during this second changeover was present in the drip pans during the remainder of the activity.

<u>Hose Disconnect-A/B</u> (2309-2357, Day 7)

During this time period, an A/B connected product hoses to the port manifold for tanks 1, 2, and 3 across. Exposure sample SB-83 was collected on the A/B.

The A/B went through the same procedure for each hose. He would

- o unbolt the blank from the manifold flange,
- o unbolt the blank from the product hose, then
- o bolt the product hose to the manifold pipe.

All of this work was performed while standing or squatting on the grate in the drip pan. In the latter case, his breathing zone was approximately 2½ to 3 feet above the liquid in the pan.

Discharge Stripping-2/M (1200-1315, Day 8)

During this time period, the 2/M stripped tank 6P from 1200 to 1230 and tank 6C from 1230 to 1315. Two exposure samples were collected on the 2/M. Sample No. SB-80 corresponded to the stripping of tank 6P, and Sample No. SB-79 corresponded to the stripping of tank 6C.

To view the liquid level in the tank bottom, the 2/M laid on the deck and inserted his head in a Butterworth opening. When not viewing the liquid level, he continued to lay on the deck and propped himself up on his elbows making his breathing zone one foot above the tank opening. The following tables summarize the times that the 2/M viewed the liquid level for the stripping of 6P and 6C.

Stripping of 6P

Encounter No.	Time	Duration (sec)
1	1207:50	69
2	1209:11	30
3	1210:50	21
4	1211:15	45
5	1212:20	20
6	1212:45	26
7	1213:17	30
8	1213:50	60
9	1214:57	20
10	1215:20	32
11	1215:55	35
12	1216:40	17
13	1217:30	30
14	1218:18	48
15	1220:13	30
16	1220:50	80
17	1222:22	56
18	1223:20	6
19	1223:29	28
20	1224:50	8
21	1225:01	33
22	1225:38	52

Stripping of 6C

Encounter No.	Time	Duration (sec)
1	1230:58	47
2	1234:45	18
3	1238:40	30
4	1241:12	23
5	1241:40	10
6	1241:58	63
7	1243:12	146
8	1246:40	29
9	1248:35	18
10	1249:00	27
11	1249:30	16
12	1250:50	21
13	1251:17	39
14	1252:00	18
15	1252:25	39
16	1253:14	64
17	1254:22	13
18	1254:40	88
19	1259:10	17
20	1259:40	90
21	1301:25	112
22	1303:25	25
23	1303:54	94
24	1306:00	14
25	1308:00	40
26	1308:49	215
27	1312:40	14

Discharge Stripping-C/M (1607-1630, Day 8)

During this time period, the C/M was involved in the stripping of product from tank 1C. In order to see into the tank, the C/M would lie down on the deck and place his face directly into a Butterworth opening. As the level dropped, he would periodically raise his head and signal the A/B on standby to close down on the product valve. The number of times and the durations when he checked the level is summarized on the following page.

Time	Duration (sec)
1608:08	117
1611:25	15
1613:05	5
1613:50	25
1614:15	55
1615:10	40
1617:05	35
1617:40	70
1618:13	60
1620:00	40
1621:54	26
1622:53	12
1623:20	15
1624:13	60
1625:40	15
1626:30	45
1627:30	20
1627:55	20
1628:20	60

Two exposure samples were obtained during this activity. Sample SB-114 was a personal sample that was collected on the C/M. Sample SB-76 was an area sample, which was collected at the opposite edge of the Butterworth opening from where the C/M was positioned.

Discharge Stripping-C/M (1634-1649, Day 8)

After stripping tank 1C, the C/M moved over to tank 1S to perform the same activity. The major difference between stripping tank 1S and tank 1C was that the level sightings were made through the ullage opening on the tank hatch rather than the Butterworth opening. This procedure was necessary because the pump suction was located directly under the tank hatch. The durations of the sightings at tank 1S are shown below.

Time	Duration (sec)
1637:05	12
1639:55	5
1644:15	5
1644:45	25
1645:18	12
1645:46	120

One personal (SB-107) and one area (SB-74) sample were collected during this discharge stripping activity. The area sample was collected at the ullage opening on the tank hatch.

Hose Disconnect-O/S (2225-2341, Day 9)

This hose disconnect operation occurred in conjunction with A/B1's regular watch No. 17 (2000-2400, Day 9). The activities of the O/S were very similar to those described for A/B1, and thus will not be repeated here.

Exposure sample, SB-202, was collected on the O/S during this activity.

Sandblasting-A/B (1035-1115, Day 10)

During this period, an A/B sandblasted surfaces on the stern of the ship. His activities and protective equipment were similar to those noted in the O/S sandblasting documentation on day 5 (0844-1115). A dust exposure sample, SB-D-19, was collected on this A/B.

Tank Washing and Ventilating-A/B and O/S (0600-1710, Day 11)

During this time period, an A/B and an O/S assisted in tank washing and ventilation. The exposure samples that were collected are summarized below.

Worker	Sample No.	Time
A/B	SB-117	0600-1200
	60389	0600-1200
	SB-205	1250-1710
	60392	1250-1710
O/S	SB-119	0600-1200
	60390	0600-1200
	SB-110	1200-1710
	60391	1200-1710

This A/B - O/S team was responsible for washing and ventilating tanks 1P, 1S, 2P, 2S, and 3S. The procedure for each tank was the same, and it included:

- opening forward, center, and aft Butterworth covers,
- dropping the wash hose 15 feet into the forward, center, and aft Butterworth opening for about 15 minutes each,
- setting up the discharge pump to strip wash residue from the tank and discharge it overboard.

- stripping the remaining liquid from the tank after washing had been completed,
- setting up a water driven blower on the Butterworth opening furthest from the man entry hatch, and
- closing of the man entry hatch and all of the Butterworth openings.

The A/B and O/S were exposed to product vapors primarily while gauging during the stripping of the tanks. These gauging activities are summarized below.

A/B Gauging Activity During Tank Washing

Encounter No.	Tank	Time	Duration (sec)
1	1P	0630:10	10
2	1P	0635:00	60
3	1P	0639:20	100
4	2C	0648:12	26
5	2C	0700:00	10
6	2P	0833:00	120

O/S Gauging Activity During Tank Washing

Encounter No.	Tank	Time	Duration (sec)
1	1P	0652:00	60
2	2C	0655:00	300
3	2S	1102:00	60

These gauging activities were performed at the open expansion trunks. The A/B or O/S would kneel or lean over by the hatch. In this position, their breathing zones were roughly six inches below the top lip of the expansion trunk. A mirror or a flashlight was used to illuminate the bottom of the tank.

Tank Cleaning-C/M and O/S (0600-1700, Day 11)

The tank cleaning activities performed by the C/M and O/S were very similar to those discussed previously for the A/B and O/S team during this same time period. The C/M and O/S, however,

cleaned all tanks aft of the loading manifold (No. 3, No. 4, No. 5, and No. 6 tanks). Both active and passive occupational exposure samples were collected on the C/M and O/S as summarized below.

Worker	Sample No.	Time
C/M	SB-103	0600-1200
	63765	0600-1200
	63777	1240-1405
O/S	SB-209	0600-1200
	63760	0600-1200
	SB-207	1215-1700
	63775	1215-1700

During the first time period both individuals were involved in washing the tanks (blowers were not connected until after lunch). For the tank washing and blowing procedure, see the previous section entitled "Tank Washing and Blowing-A/B and O/S (0600-1170, Day 11)".

Except for the No. 6 wing tanks, the liquid level was sighted through the tank hatches. For 6S and 6P the C/M looked through the Butterworth opening directly above the pump suction.

Tank washing and stripping of the No. 6 wings occurred during the initial portion of the second sampling period.

Ambient hydrocarbon concentrations on the deck were 10 - 20 ppm as methane with excursions to 200 - 300 ppm as methane. Hydrocarbon levels at the tank hatches and Butterworth openings, where the C/M made his sightings, usually exceeded 1000 ppm as methane.

XI. Deckhouse and Engine Room Environments

Deckhouse Environment

OVA surveys were conducted at all levels of both the deckhouse and engine room throughout the voyage to allow assessment of the relative potential for vapor infiltration into living spaces.

The deckhouse vapor concentrations for loading, laden, discharging, and tank cleaning are presented in Table VIII. These concentration values represent the average of the measurements taken during the various surveys. The deckhouse surveys indicated a general increase in vapor concentration during cargo loading and tank cleaning, which could be a result of infiltration through incompletely closed forward or aft access doors, or both. During loading, the odor of gasoline was noticeable, especially in the hallway to the boatdeck leading to the forward access door.

In addition to the OVA surveys during tank washing and blowing, continuous concentration measurements were made in the SwRI quarters, which was believed to contain typical deckhouse vapor levels, using an OVA connected to a strip chart recorder. This concentration time history is included as Figure 4. On this figure, the higher concentration periods are correlated with specific events. Since washing or blowing of the aft tanks did not necessarily raise the vapor concentration in the deckhouse, it seems that factors such as wind speed, wind direction, and how tightly the doors are sealed are the determining factors in the infiltration into the deckhouse.

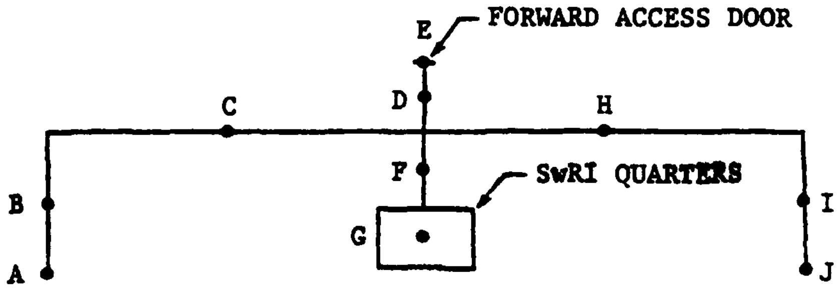
During tank washing and blowing, area samples were placed both in the SwRI quarters and engine control room, and they are designated in Table VIII as boat deck level G and main deck level F, respectively. The samples collected are summarized in Table IX.

TABLE IX. AREA SAMPLES FOR TANK WASHING AND BLOWING

Voyage Day	Location	Sample Time	Sample No.	Concentration BNZ	Concentration THC	Duration (min)
11	SwRI Qrtrs.	0600 - 1430	SB-94	0.30	5.80	482
11	Engine Control Rm.	0600 - 1430	SB-91	0.36	9.14	489
11	SwRI Qrtrs.	1430 - 1820	SB-9	ND	1.08	247
11	Engine Control Rm.	1430 - 1820	SB-5	ND	ND	238

TABLE VIII. OVA SURVEYS OF DECKHOUSE

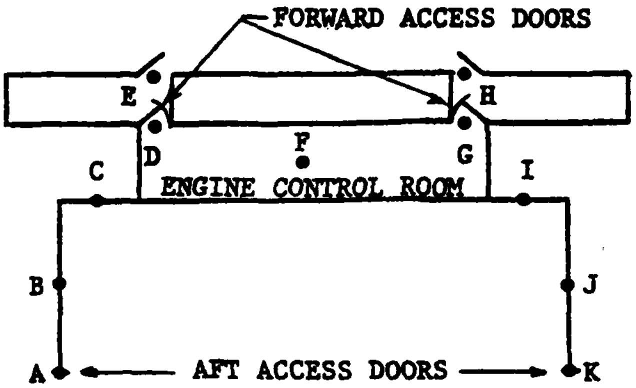
BOAT DECK LEVEL



Vapor Concentrations (ppm Gasoline)

Point	Tank Cleaning	Loading	Laden	Discharging
A	12.5	25	10	5
B	12.5	26	10	5
C	12.5	26	10	5
D	10	43	11	5
E	11	45	11	5
F	11	36	10	5
G	11	33	10	5
H	11	30	10	6
I	12.5	27	10	7
J	11	27	11	11

MAIN DECK LEVEL



Vapor Concentrations (ppm Gasoline)

Point	Tank Cleaning	Loading	Laden	Discharging
A	12.5	-	10	5
B	12.5	23	10	5
C	11	23	10	5
D	-	-	10	5
E	-	-	7	7
F	7	26	10	5
G	18.5	-	7	5
H	-	-	7	7
I	7	30	11	5
J	11	27	10	5
K	10	-	10	5

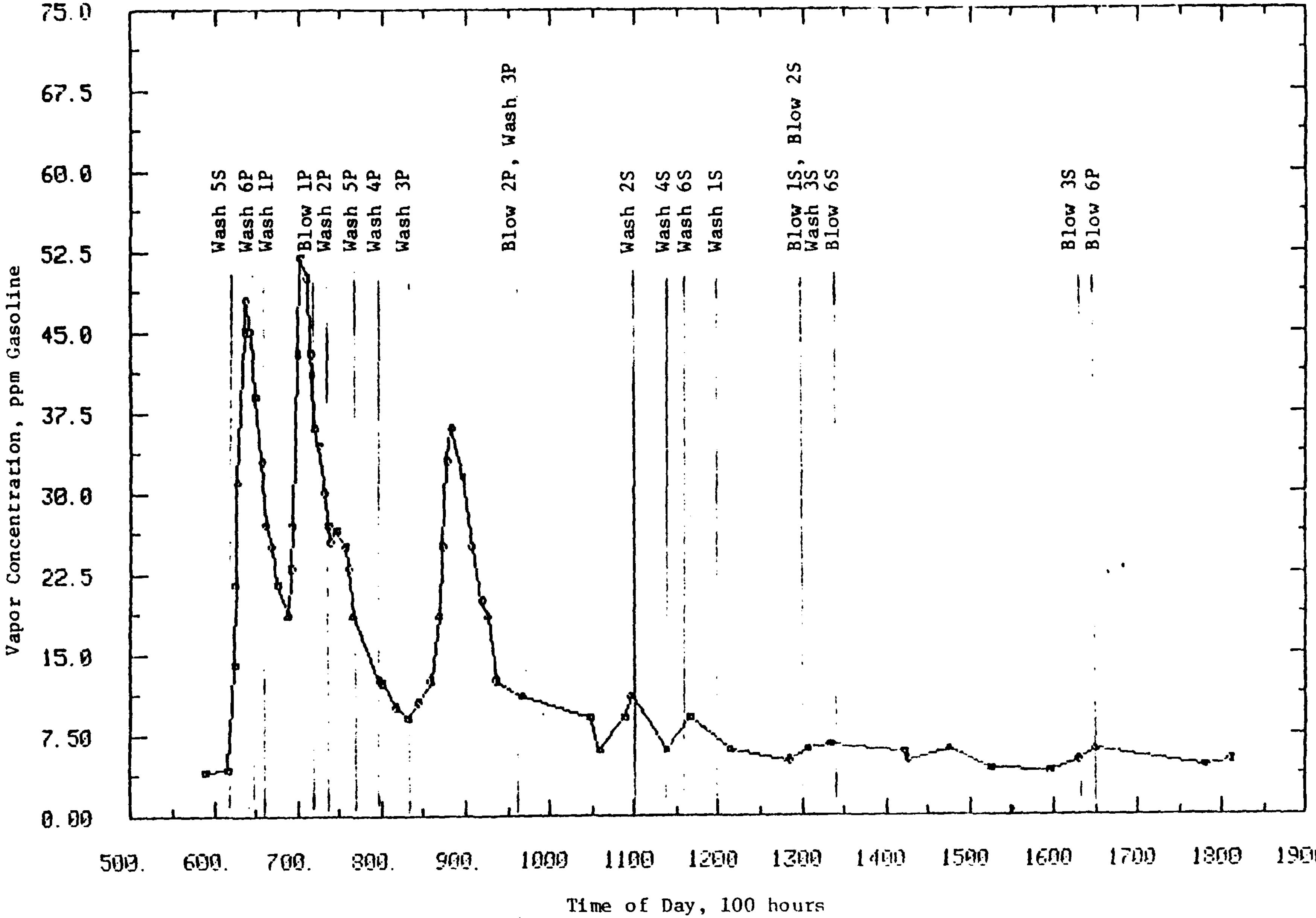


FIGURE 4. VAPOR CONCENTRATION IN SwRI QUARTERS DURING TANK WASHING AND BLOWING

The deckhouse vapor concentrations during ballasting are presented in Table X (on the following page). Because of the variation over time of these values, they are presented at the times the surveys were taken and have not been averaged. Continuous concentration measurements in the SwRI quarters were also recorded during ballasting and appear as Figure 5. Significant events designated on this figure indicate that:

(1) vapor concentrations in the deckhouse continually increased during ballasting,

(2) the peak concentration coincides with the end of ballasting, and

(3) at least two hours were necessary after ballasting was completed for the vapor concentration in the deckhouse to drop to its initial background level.

An area sample was placed in the SwRI quarters during ballasting activities. The relevant data is presented below.

Voyage Day	Sample Time	Sample No.	Concentration (ppm) BNZ	Concentration (ppm) THC	Duration (min)
9 - 10	2000-0400	SB-212	0.20	21.42	484

The bulk fuel oil sample was analyzed qualitatively for the 16 PNAs designated by the EPA. This list of compounds is partially duplicated the combined lists from NIOSH P&CAM 183 and 184. Quantitative analysis s then conducted on four of these PNAs that have ACGIH TLVs. These mpounds were o-Terphenyl, Chrysene, Benzo(a)pyrene, and Naphthalene.

The analysis of charcoal tubes for total hydrocarbon (THC) involved sorption with nitrobenzene followed by summation of gas chromatograph tegrated counts through xylene. Nitrobenzene was used because it eluted om the column after xylene and thus did not obscure low molecular weight soline components as did carbon disulfide. Total hydrocarbon content was antified against a hexane standard. Gasoline vapor concentration was lculated using an average molecular weight of 72.5.

The results of the x-ray diffraction analysis of the bulk insulation e summarized below.

	Weight Percent Asbestosform	
Sample No.	Amosite	Chrysotile
S-14	-	20-22
S-18	2-3	3-4
S-26	ND	ND
S-39	ND	ND
S-44	1	3

he designator ND signifies that the asbestos form was not detected.

The quantitative results for PNAs in the bunker fuel oil are resented below.

Component	Weight Percent	Detection Limit (μg/g)
Naphthalene	0.088	500
Chrysene	0.074	50
Benzo(a) Pyrene	0.003	20
o-Terphenyl	0.180	50

concentrations at the most frequently visited location and real-time environmental surveys using an Organic Vapor Analyzer (OVA). Occupational and area vapor samples were collected on charcoal tubes and were analyzed for benzene content and total hydrocarbon content through xylene. Short-term (15 minute) vapor sampling was not appropriate because (1) pumproom entry durations were nominally less than 15 minutes and (2) OVA surveys did not suggest that the TLV-STEL for gasoline and hence benzene would be exceeded. Work activity documentation included work task identification and duration. On selected occasions, the pumpman's noise environment was characterized. Noise dosimetry equipment was worn by SwRI project personnel.

In the engine room, full-watch occupational exposures were monitored for noise, asbestos and total hydrocarbon vapors. As in the pump room, engine room noise dosimetry was conducted for comparison against the U. S. Coast Guard Naval Vessel Circular 12-82. Asbestos was collected and analyzed using NIOSH P&CAM 239. Vapor samples were collected on charcoal and were analyzed for total hydrocarbon content through xylene. A separate analysis for benzene was not warranted because of the low vapor concentrations as determined by OVA surveys. The three dosimetry methods were distributed between the Assistant Engineer, Fireman and Oiler. The watch-to-watch distribution between personnel was varied according to a systematic plan. The motivation for vapor monitoring was possible gasoline vapor infiltration through the engine room's positive pressure dilution ventilation system.

Bulk samples of degraded insulation and bunker fuel oil were collected in the engine room. The insulation samples were analyzed by x-ray diffraction for weight percent content of various asbestos forms. The bunker fuel was analyzed for weight percent of selected polynuclear aromatic hydrocarbons. Oil mist area samples were collected on mixed esters of cellulose filters and were analyzed by infrared spectroscopy for mist concentration as mineral oil.

IV. Sampling Strategy and Sample Analysis

Prior to initiation of sampling, walk-through surveys were conducted in both the engine and pump rooms. The purpose of these surveys was to become familiar with equipment location, work stations and potential sources of airborne contaminants. Based on these surveys it was concluded that

- o neither location contained easily-identified, discrete sources of contaminant emission that would be analogous to the vapor plume that is discharged from a cargo tank during open gauging,
- o the positive pressure ventilation system in the engine room was conducive to promoting a nearly uniform distribution of contaminants within the work space,
- o pumproom operations could be controlled primarily from the deck level control console thus necessitating only brief entries to the pump/bilge level, and
- o the suction ventilation system in the pumproom was conducive to generating vertical vapor concentration gradient as opposed to a more homogenous atmosphere.

Two sampling strategies were devised prior to the test. As a result of the above observation, the following strategy was used.

In the pump room, full-shift occupational vapor exposure samples were collected on the first and second pumpman. These samples were supplemented by area vapor monitoring at the pump/bilge level to characterize the

III. Cargo Description

The cargo consisted of regular, unleaded and aviation gasolines as well as aviation jet fuel. These products were distributed as indicated in Table III.1. Loading of the entire ship took place at one terminal. Six tanks (3P, 3C, 3S, 6P, 6C, 6S) of jet fuel were discharged at anchorage to a lightering barge. The remaining products were then discharged in port.

TABLE III.1. CARGO DISTRIBTUION PLAN

Tank No.	Quantity (bbls)	Product
1P	4363	Aviation Gas
1C	12615	Aviation Gas
1S	4363	Aviation Gas
2P	5557	Unleaded Gas
2C	12611	Unleaded Gas
2S	5557	Unleaded Gas
3P	5795	Jet Fuel
3C	12612	Jet Fuel
3S	5795	Jet Fuel
4P	5812	Regular Gasoline
4C	12610	Regular Gasoline
4S	5812	Regular Gasoline
5P	5811	Regular Gasoline
5C	12604	Regular Gasoline
5S	5811	Regular Gasoline
6P	5812	Jet Fuel
6C	12594	Jet Fuel
6S	5812	Jet Fuel
7P	5792	Jet Fuel
7C	12575	Jet Fuel
7S	5792	Jet Fuel
8P	4244	Unleaded Gasoline
8C	9429	Unleaded Gasoline
8S	4244	Unleaded Gasoline
9P	5150	Unleaded Gasoline
9C	12594	Unleaded Gasoline
9S	5150	Unleaded Gasoline

operation by providing tools and operating a winch to support and remove the pipe fixture. During the laden voyage, the pump room was checked daily for leaks by either the first or second pumpman. When the vessel was discharging cargo, the operation of the cargo pumps was monitored almost continuously by one of the pumpmen.

Shifts also varied during the voyage. While the vessel was loading or discharging, the pumpmen staggered their shifts. During the laden voyage both pumpmen worked day shifts.

II.4 Deck Work

During periods of minimal cargo related activities, ship's personnel were monitored while they performed deck work. The results of this sampling are included in this report.

Substances might include paints, degreasers, asbestos lagging, etc. Alternatively, exposure might occur due to infiltration of cargo vapors into the engine room. This condition should appear on dosimetry samples as a function of voyage leg and cargo handling activities. The former type of exposure should remain more constant throughout the entire voyage.

Engine room personnel worked shifts of 4-on, 8-off during the voyage. Several individuals also worked overtime. During normal four-hour shifts, the work followed a routine, repetitive schedule of activities. For example, the oiler was required to make "rounds" every hour while underway. He inspected everything quickly, paying particular attention to gauge readings throughout the engine room. These rounds took the oiler from the propellar shaft to the stack in a period of 5 to 10 minutes. On the last round of his shift, the oiler would make sure that the personnel coming on duty for the next shift were awake.

The engineers and firemen also followed fairly routine schedules much of the time. The engineer stood near the control console almost continuously when the ship was manuevering. In open waters, the engineers were able to move away from the control panel to supervise work, perform monthly duties, etc. (Monthly duties for the engineers are given in Section V.II.) The firemen stood near the boiler control panel most of the time. They periodically moved away from the panel to check gauge readings, replace fuel injection tips and adjust valves.

II.3 Pump Room

Activities in the pump room varied considerably. During loading operations, there was generally no need to use the pump room cargo pumps. On this voyage, maintenance workers came on board to remove a faulty line from one of the pumps. The pumpman on duty assisted the

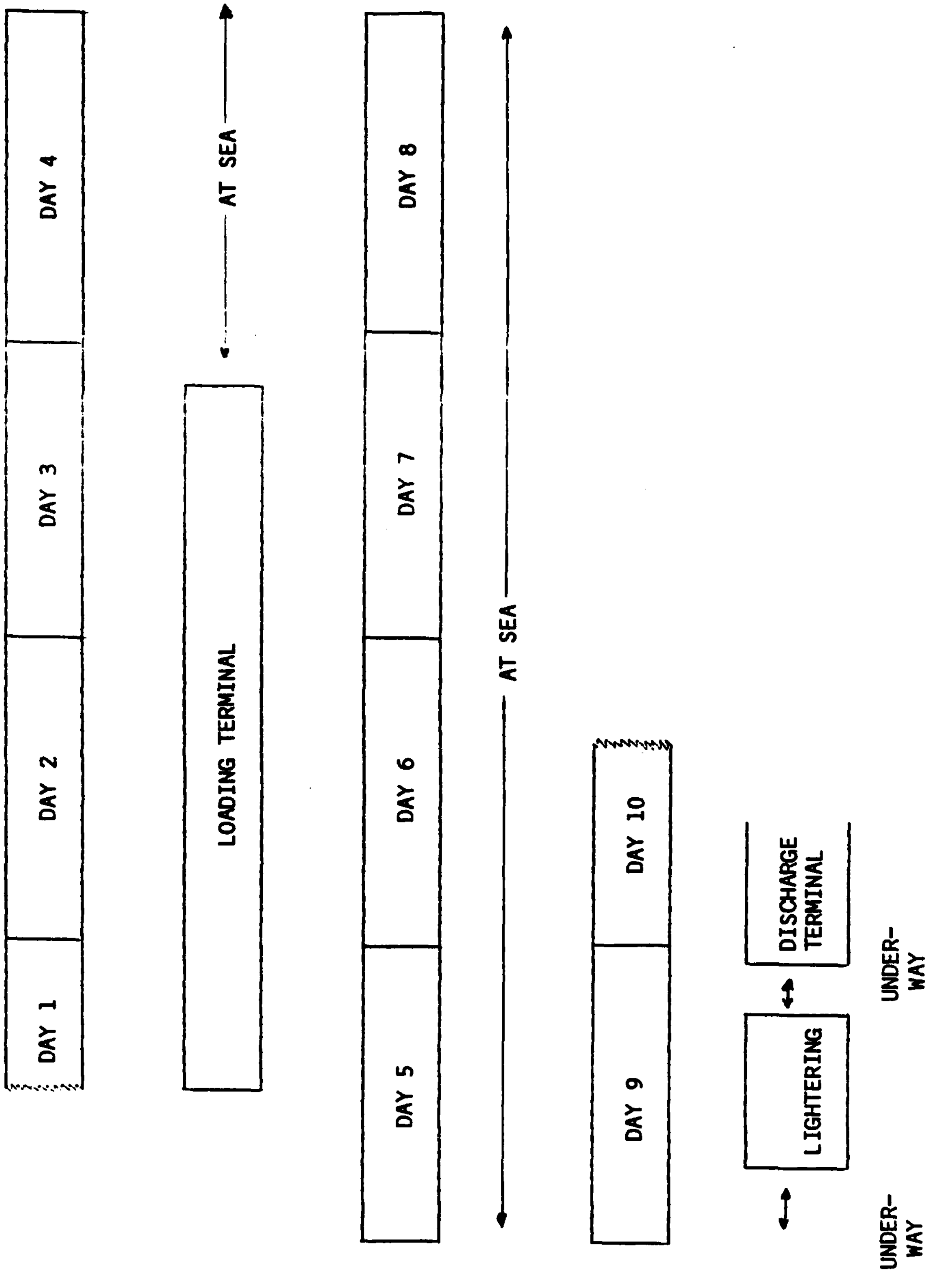


FIGURE II.1. OVERVIEW OF TIME SPENT LOADING, LADEN, AND DISCHARGING

II. Trip Overview and Objectives

II.1 General

The primary purpose of this trip was to monitor engine room and pump room personnel during various legs of the voyage. Based on prior observations on board other vessels, the loading, laden voyage, discharge, ballasting, tank cleaning, and gas freeing operations could produce a wide range of vapor concentrations on deck, and possibly inside the engine room. The objective was to monitor the engine room during each of the operations listed. However, changes in the ship's schedule precluded monitoring during ballasting, tank cleaning, or gas freeing.

Most of the pump room monitoring was conducted during the loading and discharging of cargo. During the laden voyage deck work was monitored, including chipping and painting. This monitoring was conducted during periods when sampling in the engine room and the pump room was not expected to provide additional exposure information. Figure II.1 provides an overview of the duration of each leg of the voyage. The vessel was docked at the loading terminal for approximately two full days. During this time, loading was interrupted due to electrical storms in the area. The laden voyage spanned a period of approximately 5-1/2 days. The ship was lightered to a barge for approximately 12 hours and then sailed for several hours to the discharge terminal.

II.2 Engine Room

Activities in the engine room generally follow a fairly routine schedule. Therefore, exposure to a hazardous substance was expected to occur in one of two ways. First, a normal activity might result in exposure to a hazardous substance carried in the engine room.

I. Vessel Description

I.1 Dimensions

- o Length Overall - 604'
- o Length between perpendiculars - 573'
- o Breadth (mid) - 78'
- o Depth (mid) - 44'

I.2 Tonnage - 27,000 DWT

1.3 Propulsion - Steam-turbine; 15,000 horsepower

1.4 Cargo Tanks - 27 (nine rows of three across, wing capacities symmetric about center longitudinal

1.5 Cargo Pumps - Five steam driven pumps in pumproom

1.6 Cargo Loading Method - Closed Drop

VOYAGE 2 REPORT OUTLINE

I. Vessel Description

II. Trip Overview and Objectives

III. Cargo Description

IV. Sampling Strategy and Sample Analysis

V. Engine Room

VI. Pump Room

VII. Miscellaneous

APPENDIX B

VOYAGE REPORT - VOYAGE 2

Engine Room Environment

The engine room vapor concentrations during loading and at sea are presented in Table XI. Due to these low concentrations and spot OVA checks during other phases of the voyage, personal sampling was not justified.

TABLE XI

Engine Room Vapor Concentration Measurements
(ppm as Methane)

Level	Location	Loading	At Sea
I	Spare Parts Room	8	6
	Compressor	8	5
	Engine Exhaust Ducts	8	7
	Fuel Separator	8	6
	Hydraulic Steering Room	8	6
II	Work Bench and Tool Rack	8	6-7
	Engine Cylinder Covers	8	6-7
	Engine Cooling Air Outlet	8	6-7
III	Forward Transfer Pump	8	6-7
	Bucket of Degreaser	8	6-7
	Engine Fuel Racks	8	6-7
	Clutch and Reducer	8	6-7
IV	Propeller Drive Shaft	8	6-7

NOTES:
1. Within a given level, locations progress from forward to aft end of engine room.
2. Measurements made with OVA.
3. Vapors were not analyzed for composition.

One area sample was collected in the engine room during a laden leg of the voyage. The sample was placed above the engine cylinder covers on level II, on the recommendation of the 1st Engineer. The relevant data is presented below.

Voyage Day	Sample Time	Sample No.	Concentration BNZ	Concentration THC	Duration (min)
5	1134 - 2056	SB-62	ND	0.34	562

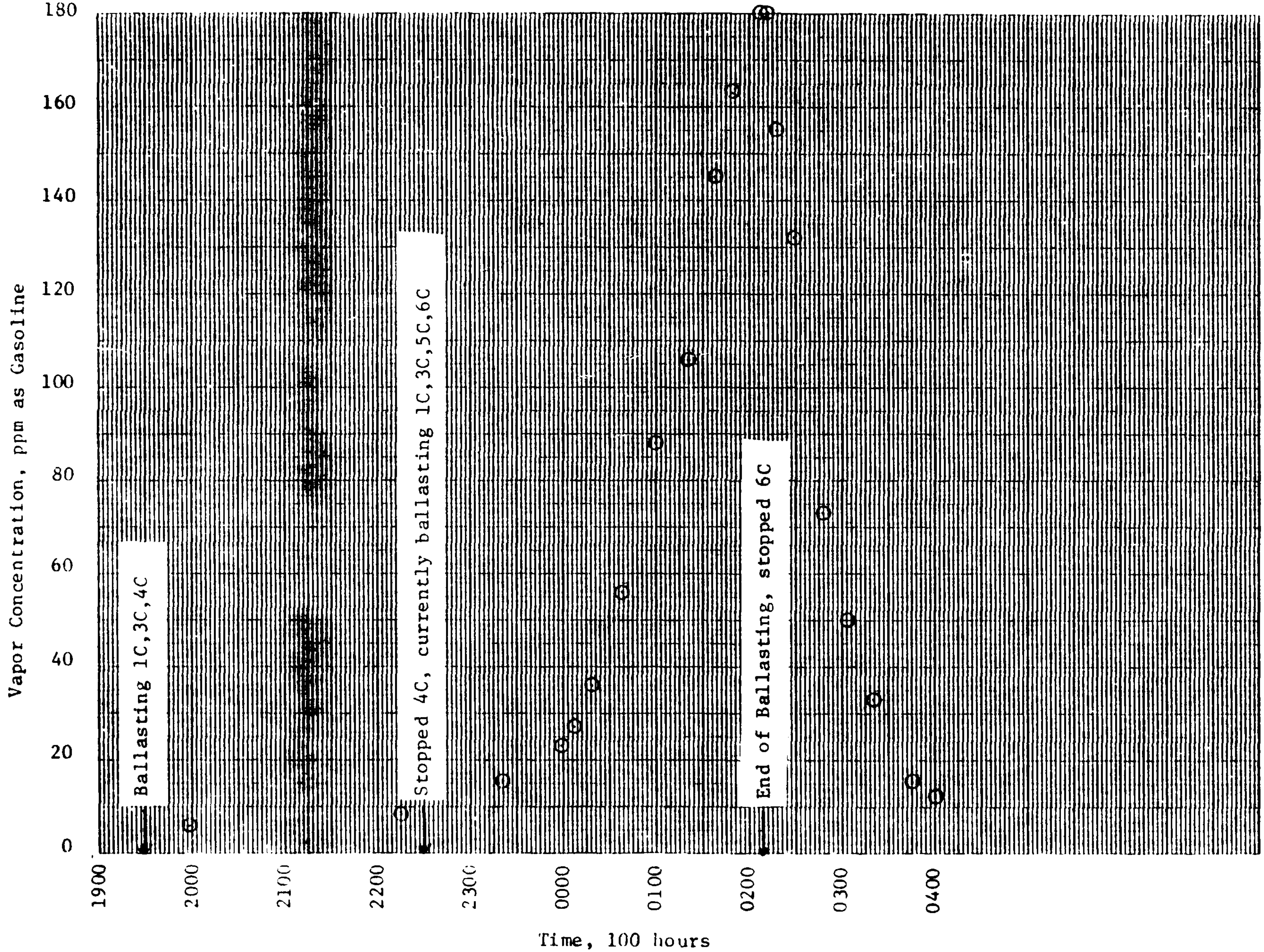
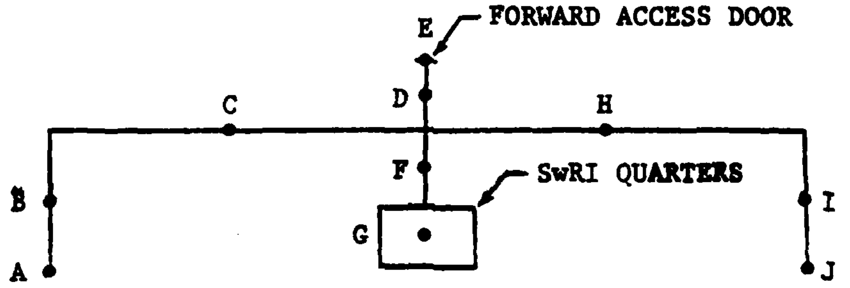


FIGURE 5. VAPOR CONCENTRATION TIME HISTORY IN SwRI QUARTERS DURING BALLASTING

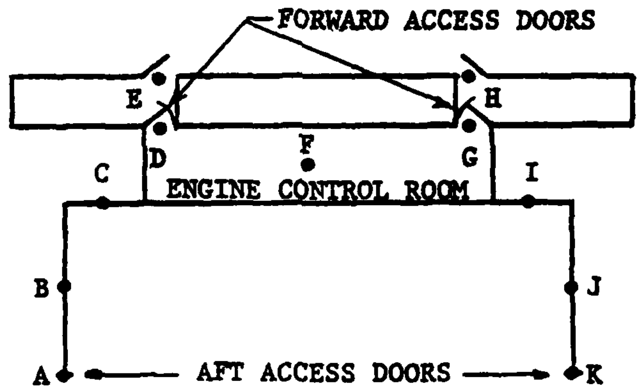
TABLE X. OVA SURVEYS OF DECKHOUSE DURING BALLASTING, DAY 10

BOAT DECK LEVEL



Point	Vapor Concentrations (ppm Gasoline) At Times: 0023	0100	0135	0210	0303	0345
A	54	50	151	190	21.5	14
B	45	86	145	190	46	17
C	43	86	145	168	48	17
D	86	102	260	285	31	14
E	145	104	285	235	31	11
F	41	88	145	185	48	15.5
G	38	88	145	178	50	15.5
H	45	88	149	190	45	18.5
I	45	92	151	190	41	18.5

MAIN DECK LEVEL



Point	Vapor Concentrations (ppm Gasoline) At Times: 0023	0100	0135	0210	0303	0345
A	63	102	140	168	30	12.5
B	63	99	170	190	33	14
C	63	97	140	168	33	14
D	60	99	178	155	30	14
E	190	102	122	140	25	12.5
F	82	102	190	168	20	11
G	99	122	285	132	10	12.5
H	145	155	850	190	-	-
I	58	97	138	122	33	14
J	60	95	138	140	33	12.5
K	72	112	140	155	31	11

V. Engine Room

V.1 Configuration and Ventilation

The engine room consisted of three primary levels. These levels included the "shaft level", the "control room level", and the "workshop level". The aft section of the shaft level contained steam condensors, lube oil coolers and purifiers, gear boxes, and the propeller shaft. The forward section contained five motors for driving discharge pumps located in the pump room. The motor shafts passed through a bulkhead separating the engine room and the pump room. The aft room on the control level contained a low pressure and a high pressure turbine, two steam turbines and alternators, an electrical breaker panel, and the control console. The fire room was forward of the control room. It housed the low pressure and high pressure boilers, a condensate box, a fuel oil heater, a storage area enclosed with expanded metal, and a fire control panel. The workshop level contained a storage area for tools, reference books, pipes, circuit breakers, etc. The forward portion of this level provided access to the upper half of the boilers.

Supply air for engine room ventilation was brought in through four inlets located two levels above the "poop deck". Figure V.1 shows the geometry of the air intake vents for the engine room. These vents were located one level below the engine exhaust stack level. The exhaust vents in Figure V.2 were located on the engine exhaust stack level. Figure V.3 shows the locations of the engine room inlet and exhaust vents in planview. Table V.1 shows the air flow velocities measured at an inlet and at an exhaust vent. The measurements were made by holding a mechanical vane anemometer in the flow at the locations indicated in Figures V.1 and V.2. These locations were roughly at the centers of equal areas. Ventilation flow rate based on inlet conditions was about 9300 cfm. The calculated discharge flow rate was close to 1050 cfm. The difference between these numbers represents the flow rate of air that was discharged from the engine room through other openings such as the access opening to the stack shroud.

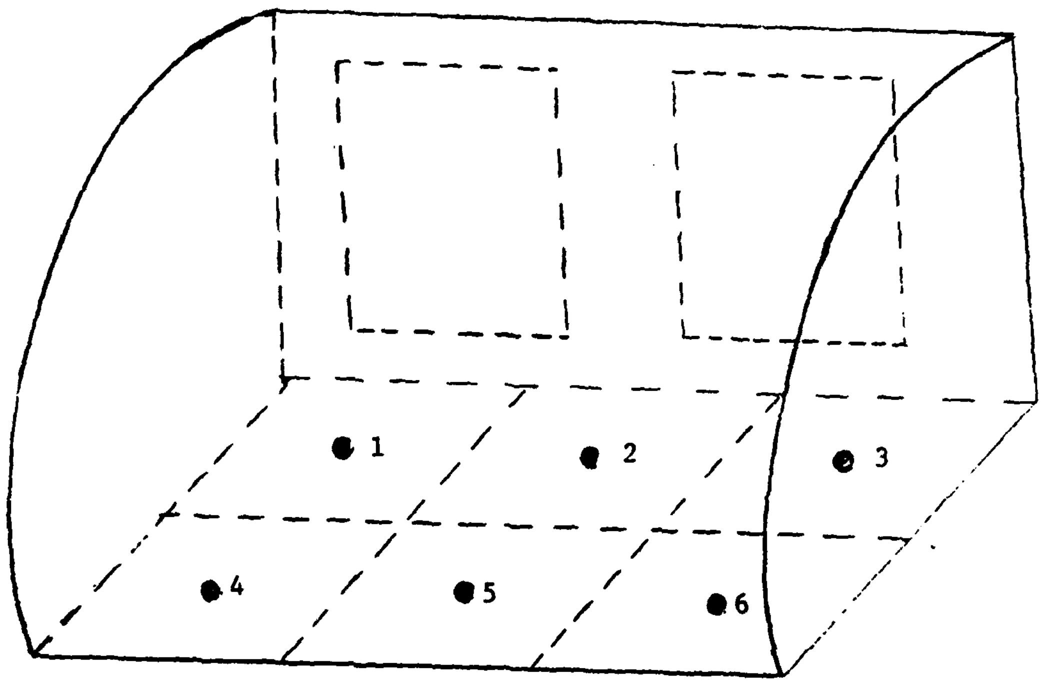


FIGURE V.1. INLET GEOMETRY

● VELOCITY MEASUREMENT LOCATIONS

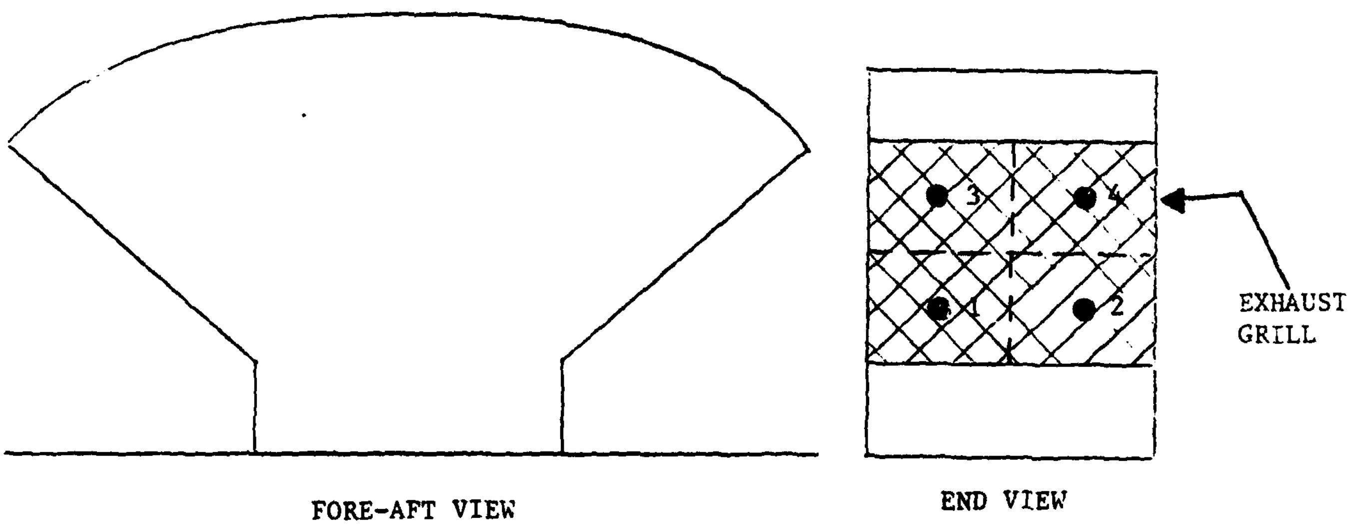


FIGURE V.2. OUTLET GEOMETRY

● VELOCITY MEASUREMENT LOCATIONS

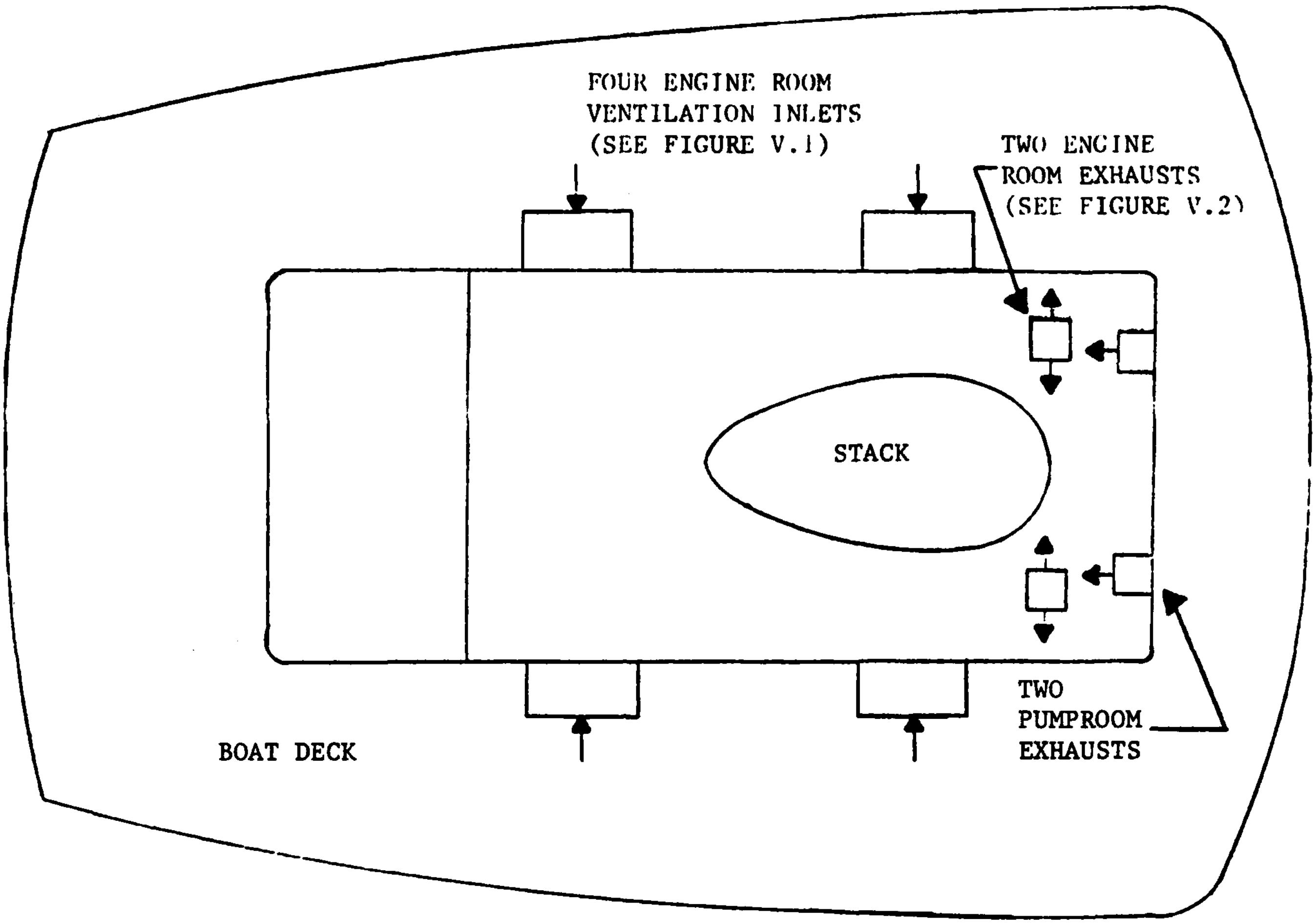


FIGURE V.3. ENGINE ROOM VENTILATION INLETS AND EXHAUSTS

TABLE V.1. VENTILATION AIR FLOW VELOCITIES (m/sec)

Location	Inlet	Exhaust
1	4.9	2.1
2	5.9	1.4 (2.0)*
3	5.8	2.2
4	5.2	2.8 (3.2)*
5	2.8	--
6	3.7	--

*Numbers in parenthesis indicate the velocity recorded on a second measurement.

Inside the engine room, spot ventilation was provided in areas where the men normally stood during a watch. Air flow velocities were measured at head level (approximately 5-1/2 to 6 feet) for several of these vents. The measurements were made at locations where the engineers, oilers, and firemen stood during their watches. The location of the measurement points in the control room and in the fire room are shown in Figure V.4. The corresponding flow velocities are given in Table V.2. The location of sample points in the shaft level of the engine room are indicated in Figure V.5. Table V.3 shows the velocities measured on the shaft level.

TABLE V.2. SPOT VENTILATOR FLOW RATES - CONTROL ROOM AND FIRE ROOM

Location ID	Description	Flow Rate, m/s
A	Ventilator for fireman; used occasionally while monitoring fire control panel	2.6
B	Fireman's normal position while monitoring fire control panel; temperature at panel 110°F	6.7
C	Control console; steam control position	1.4
D	Control console; duplexer position	1.4
E	Seat (measurement taken at head level while seated)	6.5
F	Seat (measurement taken at head level while seated)	5.8

TABLE V.3. SPOT VENTILTOR FLOW RATES - SHAFT LEVEL OF ENGINE ROOM

Location ID	Description	Flow Rate, m/s
A	(Ventilators A, B, C, and D were located in the room directly below the boilers. This	2.4
B	room contained low pressure feed water pumps and the cargo discharge pump motors. Tem-	4.4
C	perature in the room was 106°F. Tempera- ture in the air flow of the spot ventilators	1.9
D	was 93°F.)	4.2
E	Forward of condensors; above port side of watertight door; temperature 100°F.	3.8
F	Forward of condensors; above starboard side of watertight dock; temperature 100°F.	2.8

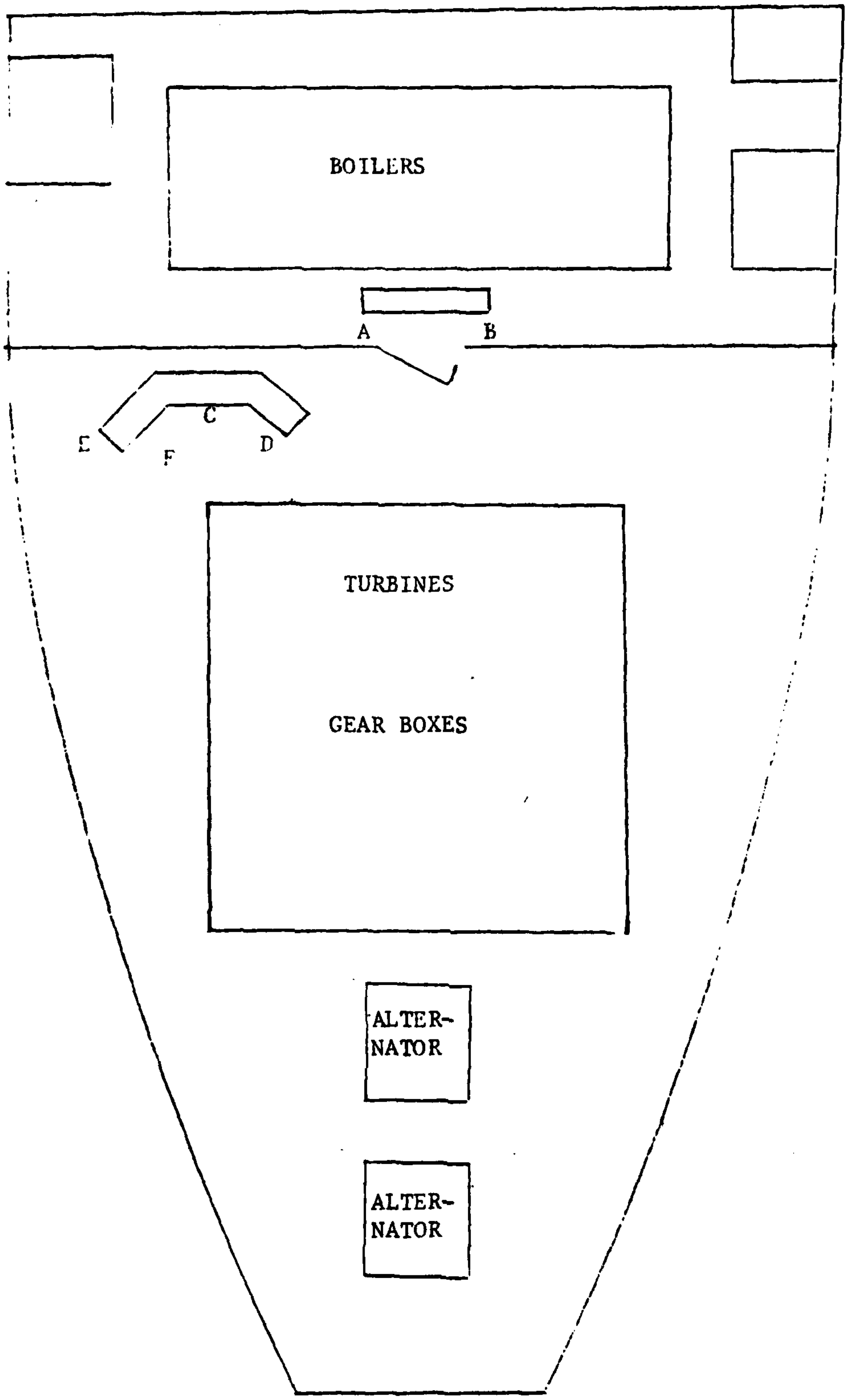


FIGURE V.4. SPOT VENTILATOR LOCATIONS - CONTROL ROOM AND FIRE ROOM

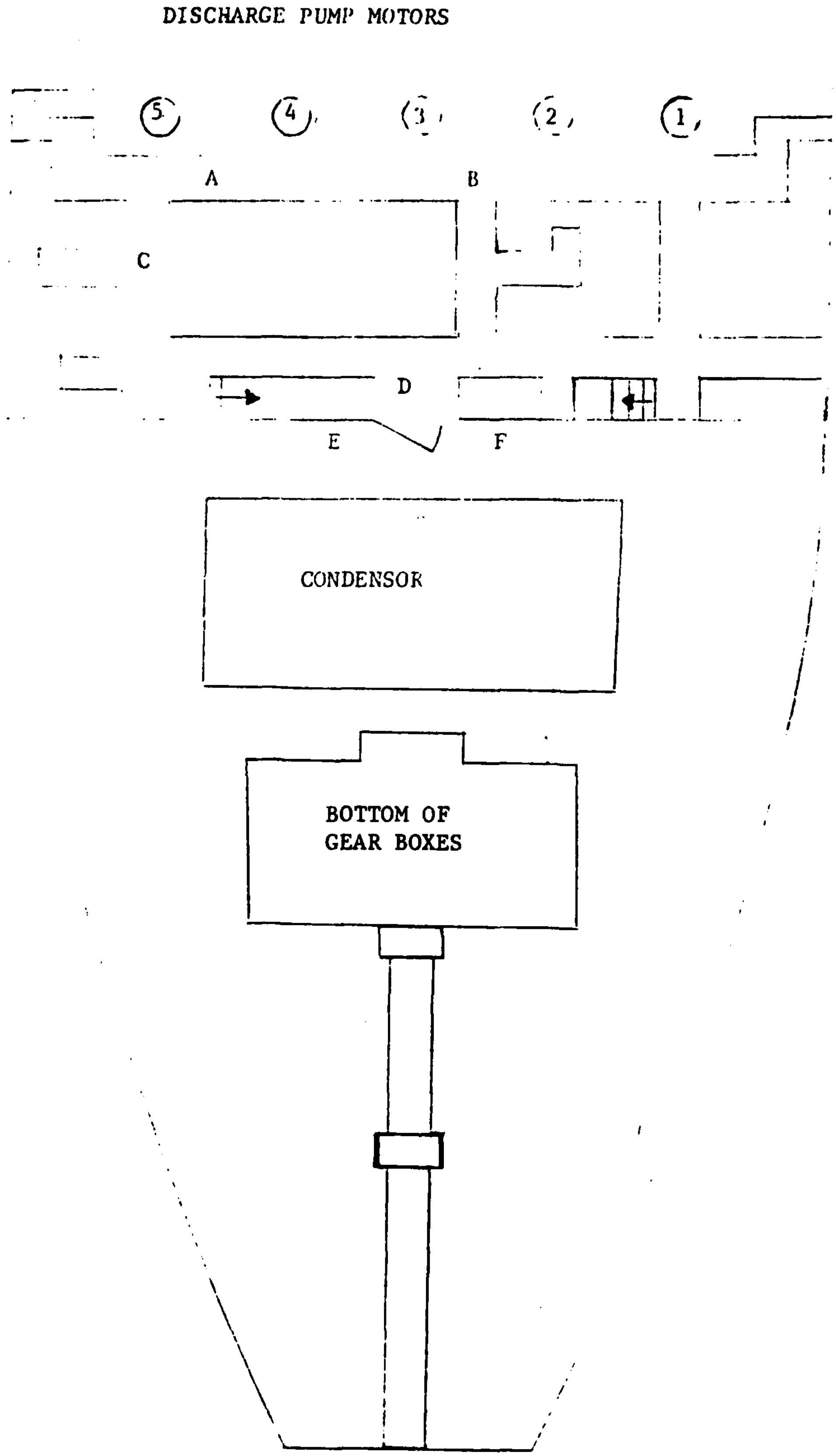


FIGURE V.5. SPOT VENTILATOR LOCATIONS - SHAFT LEVEL OF ENGINE ROOM

V.2 Schedules and Responsibilities

a. Watch Composition and Schedules

The Engineering Department consisted of:

- o Chief Engineer
- o 1st Assistant Engineer
- o 2nd Assistant Engineer
- o 3rd Assistant Engineer
- o Three Oilers
- o Three Firemen
- o Chief Wiper
- o Two Wipers

At sea, the assistant engineers work watches of 4-on, 8-off. An oiler, a fireman, and a wiper work the same shift schedule. During off-watch hours, additional work may be performed on an overtime basis. The engineers perform many of their "monthly duties" on overtime. General responsibilities and monthly duties are described in the next section.

b. Responsibilities and Duties

Duties are assigned to engine room personnel, but the duties may not be performed on every voyage. For example, the assistant engineers have a list of monthly duties which may be performed over a period of several voyages. Therefore, the exposures monitored on different voyages may differ. Tables V.4 through V.6 summarize the monthly responsibilities assigned to the first, second, and third assistant engineers.

TABLE V.4. FIRST ASSISTANT ENGINEER - MONTHLY DUTIES

1. Lubricate generator trips and governor assemblies. Test trips and log.
2. Lubricate main engine throttles and inspect tightness of holding screws.
3. Test emergency diesel speed control and trip.
4. Change over all equipment.
5. Clean faces on all thermometers and gauges.
6. Operate and free-up, if required, all salt water valves.
7. Clean stack, fwd fan room and after fan room - chip and paint, as required.
8. List brass pipe fitting requirements.
9. List tool requirements.
10. List packing requirements.
11. List oil and grease requirements.
12. List requirements of iron stock, nuts and bolts, screws and stud stock.
13. List valve requirements.
14. List paint requirements.
15. Clean and lubricate machine shop equipment.

TABLE V.5. SECOND ASSISTANT ENGINEER - MONTHLY DUTIES

1. Secure and blow down both boilers. Log. (Meg forced draft fan motor, or arrange for Third Assistant Engineer to meg it, while boiler is secured.)

2. Blow down feed water regulator, as per instruction manual; also, blow down regulator, any time the boiler is back on line after a shutdown.

3. Test run boiler test pump and log.

4. Clean ALL sootblower air filters and lubricators.

5. Take a boiler water sample from each main boiler, L.P.S.G. and condensate, just before entering Port Arthur, for analysis by Maintenance Engineering.

6. Change over feed pump, when directed by First Assistant Engineer. Change oil immediately after securing. Check for cleanliness of oil or evidence of water. Test L.O. alarm and log. See that all valves operate freely and do not leak.

7. Change over L.P. feed pump. If required, repack immediately after securing.

8. Change over fuel oil service pump, when directed by First Assistant Engineer.

9. Change over fuel oil heater, in rotation, when directed by First Assistant.

10. Clean salt water strainer on feed pump lube oil coolers supply. Log.

11. Grease soot blowers (Thermotex).

12. List requirements of high pressure pipe fittings.

13. List requirements of high pressure valves.

14. List requirements of high pressure gaskets.

15. List requirements of water test and treatment chemicals for boilers and evaps.

16. List requirements of boiler gauge glass parts and boiler gaskets.

TABLE V.6. THIRD ASSISTANT ENGINEER - MONTHLY DUTIES

1. MEGGER REPORT: Submit to Chief Engineer by the 15th of each month. Close and open main condenser overboard valve, when megging main circulator. Arrange with the Second Assistant Engineer to obtain meg on forged draft fan motors, when boilers are secured. Remove all fuses when megging running lights, and meg both lamps in each circuit. The generators are not to be cleaned or megged. (This is handled by shore staff.)

2. Check galley equipment wiring and controls, when directed.

3. Check pump room bilge alarm, with assistance of Pumpman, and log results.

4. Clean salt water strainers and log: sanitary/salt water service suction; cargo pump L.O. cooling water; evap feed pump suction; evap feed pump discharge (2); fire and general service pump suction (2); generator L.O. cooling water (2).

5. Change and clean L.O. strainer on generator, after shutdown, from load or standby.

6. Test L.O. purifier overflow alarm and log.

7. Test L.O. gravity tank low level alarm. Log.

8. List lamp locker requirements: lamps, fuses, indicator lamps, plugs, etc.

9. List galvanized pipe fitting requirements.

10. Inspect all lifeboat floodlights. Check all dogs, toggles and swivels. Ensure that light is capable of swinging in all directions. Free-up, lubricate and repair, as required.

11. Change over lube service pumps, when directed, testing automatic changeover, main turbine L.O. trip and L.O. failure alarm. (In port only.)

12. Change over auxiliaries when directed by the First Assistant Engineer.

13. Change and clean main L.O. strainers. (In port only.)

14. Clean refrigeration condensers, on galley, saloon and crew messroom refrigerators, all scuttlebutts and ice cube maker.

V.3 Work Activities and Monitoring

Engine room personnel were observed and monitored at various imes throughout the voyage. Several time-motion observations were onducted in conjunction with personal sampling for hydrocarbons, asbestos, nd sound pressure levels. These observations indicated that the engine oom operates on a work schedule which is much more stable than the Deck epartment's schedule. As a result, the number of samples collected during ach shift was increased. The collection of a greater number of samples recluded the detailed documentation of activities which normally ccompanies each sample. In the remainder of this section we have resented a summary of activities, a record of samples collected, and abulated results of the analyses performed on each sample.

During loading, an OVA survey was conducted in the engine room the results of this survey are reported in Section VII). Also during oading, an assistant engineer wore a personal sampler for determining otal hydrocarbon level. This was Sample No. SB-96 as shown in Table V.7, hich summarizes all engine room exposure samples. The assistant engineer upervised work which the oiler was performing in the machine shop. He also walked around the engine room inspecting all areas and filled out a og of work for the next shift to perform. The results of this sample are eported in Table V.8, which contains a summary of all personal sampling esults for the engine room. Extended vapor exposure monitoring was not onducted during loading because the

- o ambient wind direction was not conducive to infiltration of cargo vapors into the engine room ventilation system and

- o OVA surveys indicated vapor concentrations were not substantially different from the ambient background.

While underway, SwRI collected time-motion data and personal samples on an oiler and a fireman. These observations also indicated that the engine room personnel followed fairly routine schedules. The fireman monitored the operation of the boilers. He was responsible for cleaning the burners and adjusting valve settings as required. The majority of his watch was spent in a very small area of the engine room. Likewise, the oiler had very specific duties. He made "rounds" every hour to check the entire engine room. This inspection normally required less than 10 minutes to complete. The assistant engineers generally remained close to the steam control valves while underway. They would periodically check the work being performed by the other engine room personnel. The wipers had the greatest variety in the location of their work. They might be assigned to clean or paint in a different area of the engine room during each shift. On this voyage, most of the work performed by the wipers occurred near the steam control panel.

Based on these observations, a sampling pattern was set up which required the assistant engineer, the oiler, and the fireman to wear two samplers simultaneously. The type of samples available were total hydrocarbon, asbestos, and sound pressure level. The combination was rotated at each shift. Table V.7 indicates the samples collected on each shift. Table V.8 summarizes the results of the engine room personal sampling for hydrocarbons and asbestos.

Area samples for total hydrocarbons, asbestos, and noise were also collected near the control panel for the boilers. The placement of these samples was chosen based upon a walk-through inspection of the engine room. Lagging on a pipe almost directly above the spot where the fireman stood was cracked and open. The sample was placed below the cracked lagging. The noise dosimeter was set up as a stationary monitor because the fireman appeared to spend most of his watch at one spot.

TABLE V.7. ENGINE ROOM PERSONAL SAMPLING

: 2

FT: 0800 to 1200

	Noise	Hydrocarbons	Asbestos
ler			
reman			
sistant Engineer		SB-96	

': 3

FT: 1822 to 2000; 2000 to 2200

	Noise	Hydrocarbons	Asbestos
ller	TX-10*	TX-108	M-118
ireman	TX-9*	SB-32	M-113
ssistant Engineer			

*Worn by SwRI Personnel

': 5

IFT: 0800 to 1200

	Noise	Hydrocarbons	Asbestos
ller		CG2-025	M-123
ireman	TX-11A		
ssistant Engineer	TX-13A	CG2-029	

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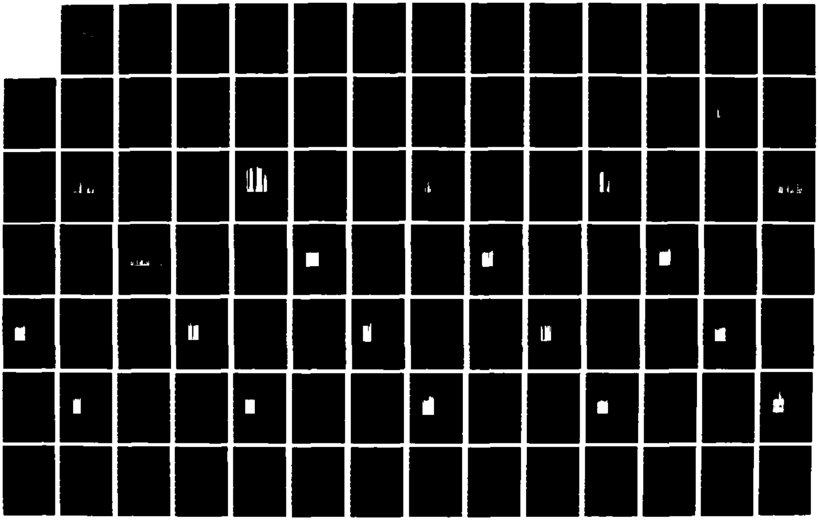

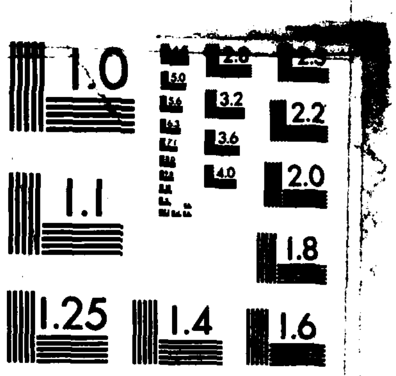

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE V.7. ENGINE ROOM PERSONAL SAMPLING (Continued)

DAY: 5

SHIFT: 1200 to 1600

	Noise	Hydrocarbons	Asbestos
Oiler	TX-12A	CG2-022	
Fireman		CG2-028	M-154
Assistant Engineer	TX-13B		M-150

DAY: 5

SHIFT: 1600 to 2000

	Noise	Hydrocarbons	Asbestos
Oiler	TX-12B		M-160
Fireman	TX-11B	CG2-023	
Assistant Engineer		03-P11	M-140

DAY: 6

SHIFT: 0800 to 1200

	Noise	Hydrocarbons	Asbestos
Oiler	TX-14A		M-132
Fireman	TX-15A	CG2-026	
Assistant Engineer		CG2-024	M-124

TABLE V.7. ENGINE ROOM PERSONAL SAMPLING (Concluded)

DAY: 6

SHIFT: 1200 to 1600

	Noise	Hydrocarbons	Asbestos
Oiler	TX-14B	CG2-021	
Fireman		CG2-030	M-162
Assistant Engineer	TX-15B		M-153

DAY: 8

SHIFT: 0800 to 1200

	Oil Mist
Oiler	M-141
Fireman	M-158
Assistant Engineer	

TABLE V.8. RESULTS OF SAMPLE ANALYSES FOR PERSONAL SAMPLING

Day	Operation	Sample ID	THC ppm	Asbestos Fibers/cc >5μ	Sample Duration min.
2	Loading	SB-96	0.749	--	155
3	Laden Voyage	M-118	--	0.0046	213
		SB-32	<0.324	--	217
		M-113	--	0.0063	213
5		CG2-025	0.75	--	232
		M-123	--	0.0051	230
		M-134	--	0.0038	225
		CG2-029	1.17	--	232
		CG2-022	1.38	--	177
		CG2-028	1.97	--	184
		M-154	--	0.0093	183
		M-150	--	0.0270	176
		M-160	--	0.037	220
		CG2-023	1.34	--	211
		03-P11	1.08	--	216
		M-140	--	0.0044	216
6		M-132	--	<0.0035	212
		CG2-026	1.82	--	221
		CG2-024	0.92	--	*
		M-124	--	<0.0043	211
		CG2-021	3.25	--	*
		CG2-030	1.95	--	223
		M-162	--	0.0063	222
		M-153	--	0.0071	222
8		M-141**	--	--	191
		M-158**	--	--	168

* The duration was not recorded. The pump count was used to calculate the THC concentration.

** Samples M-141 and M-158 were analyzed for oil mist. M-141 showed 89 μg as mineral oil and M-158 showed 110 μg as mineral oil. The resultant oil mist concentrations were 0.28 and 0.46 mg/m^3, respectively.

A summary of area samples collected in the engine room is given in Table V.9. The table indicates where the sample was taken, the ship's operating condition, and the detected level. For asbestos, the samples were analyzed using NIOSH P & CAM 239 to obtain a fiber count. The hydrocarbon samples are reported in ppm for THC. Finally, the oil mist sample was analyzed using an infrared spectrophotometry method to determine the weight as micrograms of mineral oil.

TABLE V.9. ENGINE ROOM AREA SAMPLES

Sample No.	Description of Location	Operation	Concentration*			Sample Duration min.
			A	THC	OM	
M-144	Engine room control console	loading	.0027			244
SB-17	Breathing zone level above bulge	loading		1.59		243
M-139	Forward side of boiler in fire control room	loading	0.010			204
M-111	Fireman's work station	laden voyage			0.26	249
SB-6	Fireman's work station	laden voyage		2.36		246

*A = Asbestos (fibers/cc); THC = Total Hydrocarbon (ppm); OM = Oil Mist (μg/L or mg/m^3)

The sound pressure levels (SPL's) measured in the engine room are reported in Appendix B-1 of this second voyage report. The appendix also contains a description of the procedure used to evaluate and present SPL data.

VI. Pump Room

VI.1 Configuration and Ventilation

The pump room had three levels separating the top and bottom levels. However, the pumpmen rarely spent any time on these intermediate levels. The uppermost level contained a control panel which permitted the pumpman to monitor and adjust the pumps from the top. The bottom level contained five cargo pumps and five stripper pumps.

At the bottom of the pump room five suction pickups were provided to draw air out of the pump room. There was no forced positive pressure ventilation in the pump room. Supply air was ingested passively from the deck level control panel area. As a result, flow velocities were very low. The placement of the pickups is shown in Figure VI.1. The location of the pump room exhausts is shown in Figure VI.2. Figure VI.3 shows the geometry of the pump room exhaust ducts. This figure also indicates the flow velocity and total hydrocarbon concentrations measured at the two discharge vents.

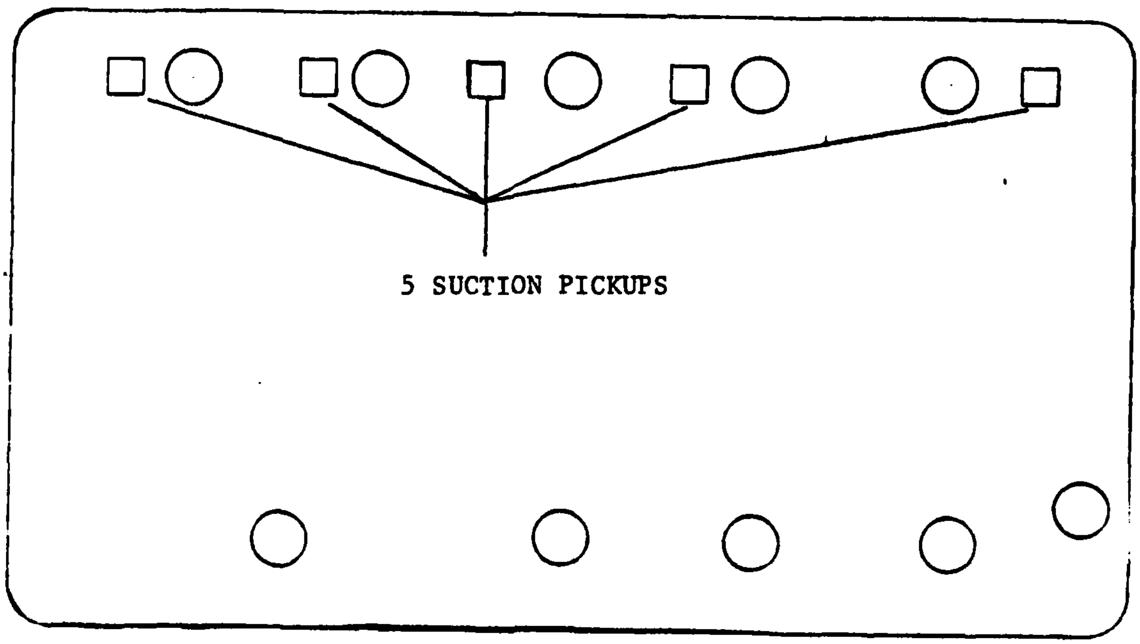

FIGURE VI.1. PUMPROOM VENTILATION PICKUPS

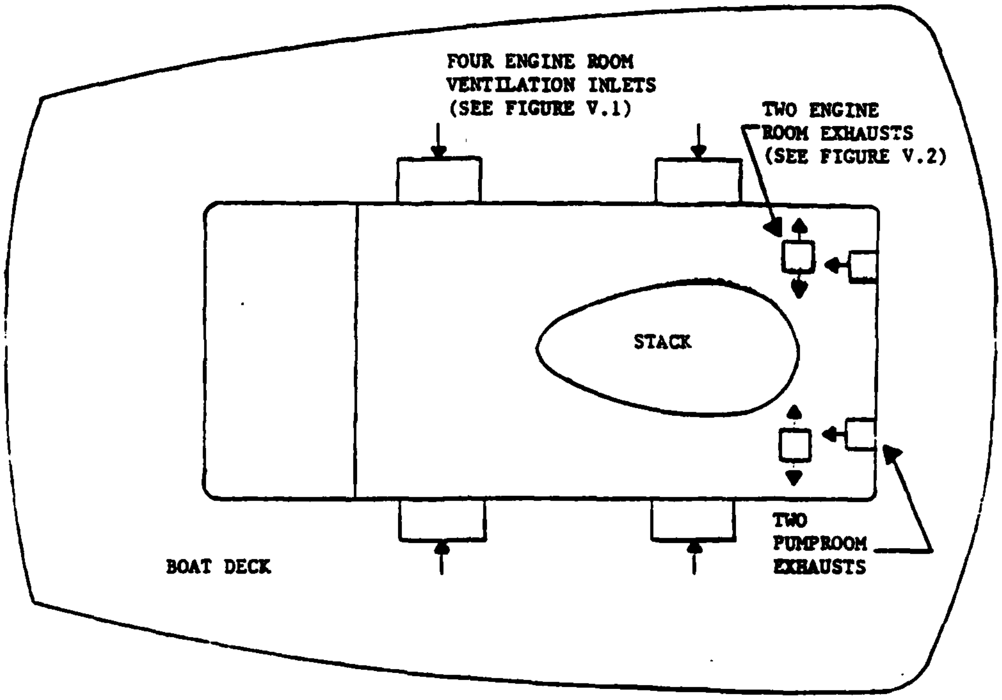

FIGURE VI.2. PUMP ROOM EXHAUST

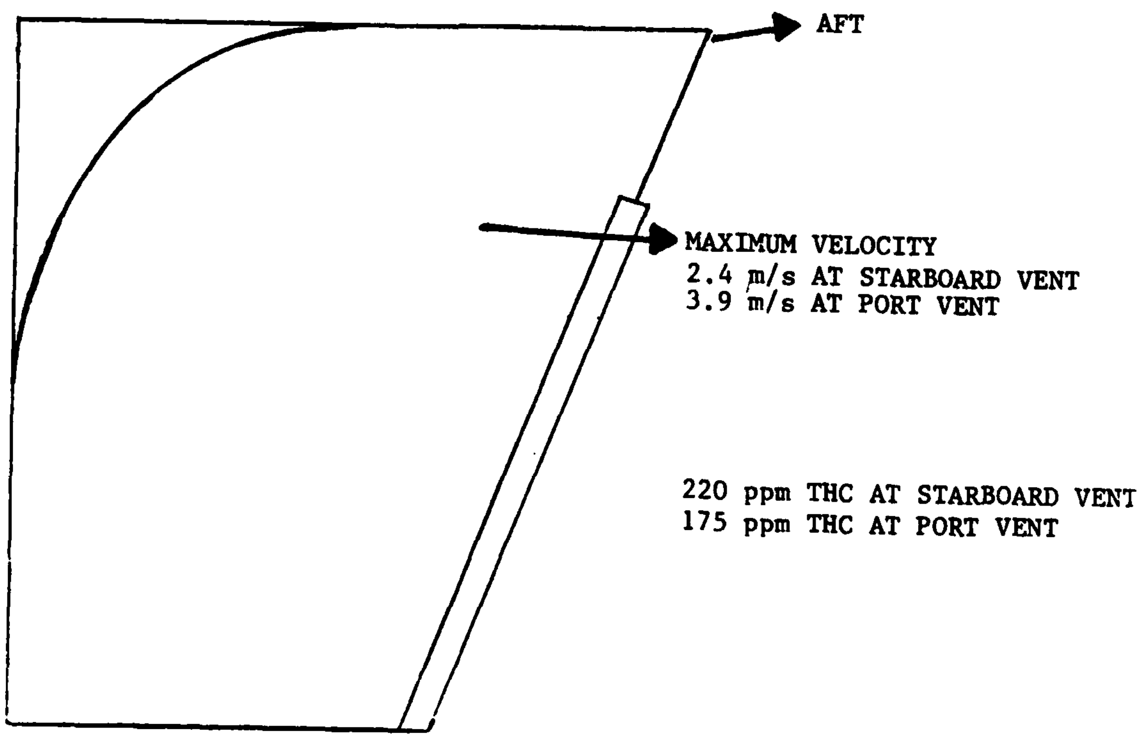

FIGURE VI.3. CROSS-SECTION OF PUMP ROOM EXHAUST

VI.2 Watch Composition

During loading and discharge the pumpmen work shifts of 8-on and 8-off. The shifts change at 0800, 1600, and 2400 hours. The chief pumpman decides who will start the initial shift. For example, the ship may dock at 0400. The chief pumpman may elect to work from 0400 to 0800 or he may wait and work from 0800 to 1600. On the laden voyage both pumpmen worked the day shift.

VI.3 Work Activities and Monitoring

The pumpmen were monitored several times during the voyage. In each case, a time-motion record was obtained for correlation with the dosimetry records. Table VI.1 shows summaries of entries into the pump room by the pumpmen. These tables also indicate the corresponding personal sample. The sample results are tabulated in Table V1.2. Area samples were also obtained in the pump room. These samples quantify the vapor concentration levels irrespective of the duration of entry into the pumproom. The results obtained from these samples are presented in Table VI.3.

TABLE VI.1. SUMMARY OF ENTRIES INTO PUMPROOM

DAY: 1

PUMPMAN: 2nd

PUMPROOM (1345 to 1845)

Entry No.	Duration	Purpose	Level	Personal Sample
1	5 min	Discuss valve leak with C.M.	Bottom	--
2	>15 min	Monitor and adjust main valve control	Top	--
3	96 min	Monitor and adjust main valve control	Top	--
4	Unknown	Set up stripper pump	Botton	--
5	9 min	Check bilge	Bottom	SB-28
6	3 min	Start bilge pump	Top	SB-28
7	4 min	Check bilge	Bottom	SB-28

DAY: 2

PUMPMAN: 2nd

PUMPROOM (0800 to 1535)

Entry No.	Duration	Purpose	Level	Personal Sample
1	12 min	Visual inspection, start steam pump	Top	TX-100
2	4 min	Check pump 1 and block valve 1	Bottom	TX-100
3	10 min	Check gaskets for pump	Top	TX-100
4	30 min	Supervise changing of gasket	Bottom	TX-100
5	3 min	Check crew working on pump	Bottom	TX-105
6	32 min	Operating air-driven winch	Top	TX-105

TABLE VI.1. SUMMARY OF ENTRIES INTO PUMPROOM (Continued)

DAY: 7

PUMPMAN: 1st

PUMPROOM (0800 to 0930)

Entry No.	Duration	Purpose	Level	Personal Sample
1	5 min	Turn on blowers	Top	--
2	70 min	Check and lubricate pumps, strippers	Bottom	--

DAY: 8

PUMPMAN: 1st & 2nd

PUMPROOM (0800 to 0845)

Entry No.	Duration	Purpose	Level	Personal Sample
1	45 min	Check for leaks and lubricate pumps. (lubricant samples obtained)	Bottom	--

TABLE VI.1. SUMMARY OF ENTRIES INTO PUMPROOM (Continued)

DAY: 9

PUMPMAN: 1st

PUMPROOM (0700 to 1543)

Entry No.	Duration	Purpose	Level	Personal Sample
1	5 min	Open valves	Bottom	--
2	11 min	Open valves; start pumps	Top	TX-113
3	3 min	Check pumps	Bottom	TX-113
4	3 min	Check pumps	Bottom	TX-113
5	1 min	Monitor gauges	Top	TX-113
6	3 min	Check pumps	Bottom	TX-113
7	11 min	Monitor gauges	Top	TX-113
8	2 min	Start small pump	Top	TX-113
9	3 min	Stop small pump	Top	TX-113
10	5 min	Check pumps	Bottom	TX-119
11	12 min	Adjust pumps	Top	TX-119
12a*	11 min	Monitoring gauges	Top	TX-119
12b	19 min	Monitoring gauges	Top	TX-127
13	4 min	Monitoring gauges	Top	TX-127
14	5 min	Check pumps	Bottom	TX-127
15	1 min	Monitor gauges	Top	TX-127
16	4 min	Monitor gauges	Top	TX-127
17	11 min	Drain sea line	Bottom	TX-127
18	2 min	Monitor gauges	Top	TX-127
19	1 min	Monitor gauges	Top	TX-127
20	4 min	Check pumps	Bottom	TX-127
21	2 min	Monitor gauges	Top	TX-127
22	3 min	Monitor gauges	Top	TX-127
23	<4 min	Check pumps	Bottom	SB-27
24	5 min	Set up pump	Bottom	SB-27
25	5 min	Check pumps	Bottom	SB-27
26	3 min	Monitoring gauges	Top	SB-27
27	4 min	Monitoring gauges	Top	SB-27

*12a and 12b are the same entry. Sample was changed inside pumproom

TABLE VI.1. SUMMARY OF ENTRIES INTO PUMPROOM (Concluded)

DAY: 10

PUMPMAN: 1st

PUMPROOM (0046 to 0640)

Entry No.	Duration	Purpose	Level	Personal Sample
1	57 min	Monitor gauges; tighten leaky pump (gasoline from leak covered 5 ft^2	Top	TX-115
2	15 min	Monitor gauges	Top	TX-115
3	2 min	Monitor gauges	Top	TX-115
4	6 min	Check pumps	Bottom	TX-115
5	30 min	Monitor gauges	Top	TX-115
6	2 min	Check pumps	Bottom	SB-34
7	2 min	Monitor gauges	Top	SB-34
8	15 min	Monitor gauges	Top	SB-34
9	8 min	Monitor gauges	Top	SB-34
10	4 min	Monitor gauges	Top	SB-34
11	2 min	Monitor gauges; shut down 4	Top	SB-34
12	4 min	Line up valves for 4 stripper	Bottom	SB-34
13	3 min	Check source of "thud"	Top	SB-34
14	18 min	Monitoring gauges	Top	SB-34
15	4 min	Check pumps	Bottom	SB-34
16	11 min	Monitoring gauges	Top	TX-107

TABLE VI.2. ANALYSIS RESULTS FOR PUMPROOM SAMPLES

Day	Operation	Sample ID	THC ppm	BNZ ppm	Sample Duration min.
1	Loading	SB-28	36.1	2.1	17
2	**Loading**	TX-100	**25.05**	**1.14**	**159**
9	Lightering	TX-105	39.07	1.4	136
		TX-113	8.6	<0.12	131
		TX-119	3.7	<0.18	92
		TX-127	9.5	<0.14	116
		SB-27	6.3	<0.15	111
10	Discharging	TX-115	4.2	<0.14	117
		SB-34	9.2	.23	120
		TX-107	4.9	<0.15	108

TABLE VI.3. PUMP ROOM AREA SAMPLES

Day	Area No.	THC ppm	BNZ ppm	Sample Duration min.	Personal Samples*
1	CG2-027	60.4	2.2	162	SB-28
9	H-37	12.2	<0.4	43	TX-113 TX-119
9	H-34	29.4	1.2	172	TX-127
9	H-36	22.5	1.5	195	SB-27
8	SB-1	58.2	2.2	237	--
10	SB-7	136.2	3.8	240	--
10	H-40	75.5	0.9	234	--
10	H-29	157.1	4.0	223	--

*Personal samples listed in this column were collected concurrently with the area samples. The concentrations recorded for the personal samples are shown in Table VI.2.

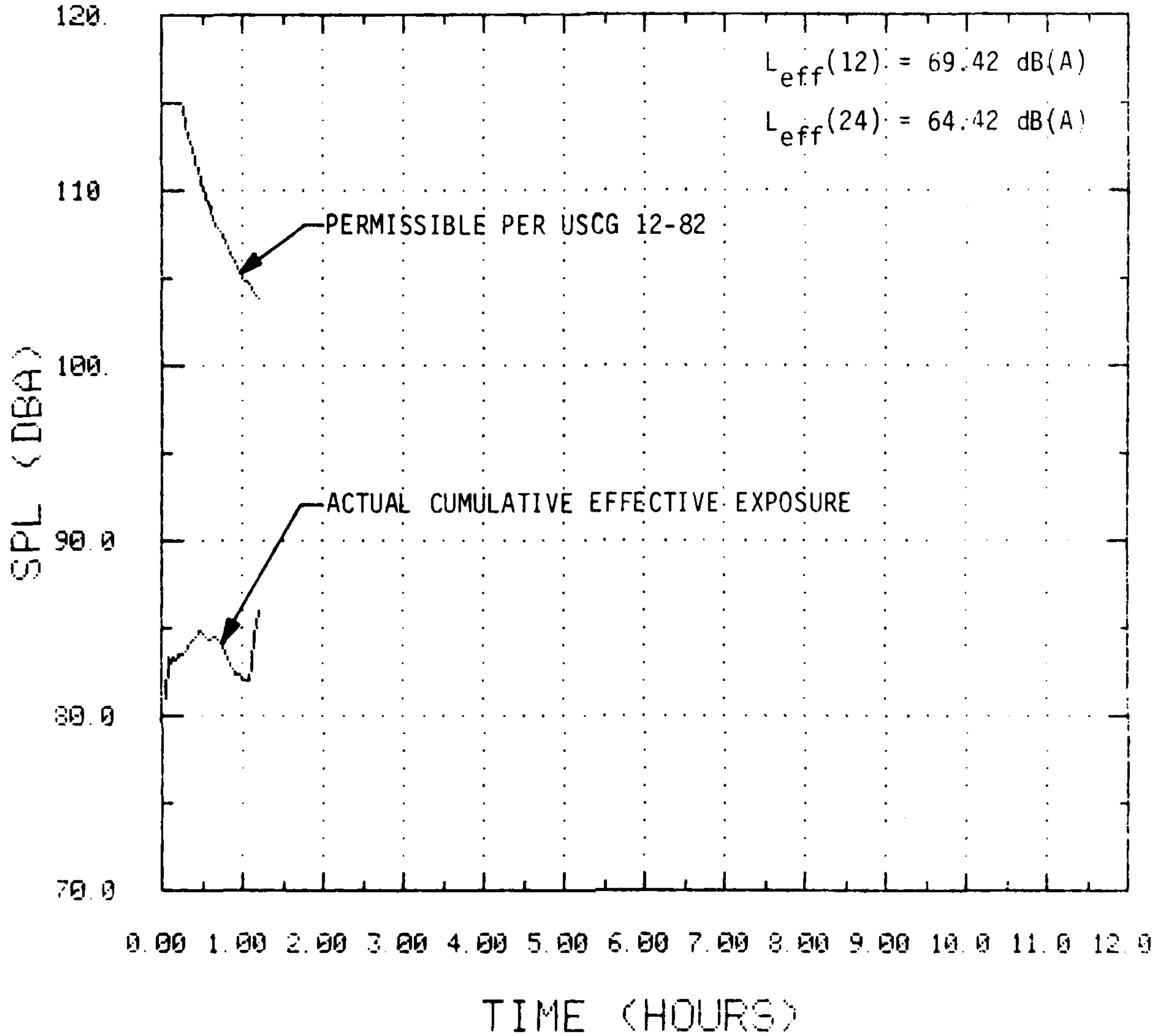

FIGURE B-2. **CUMULATIVE EFFECTIVE EXPOSURE ON SwRI PERSONNEL**
Sample No. TX-1

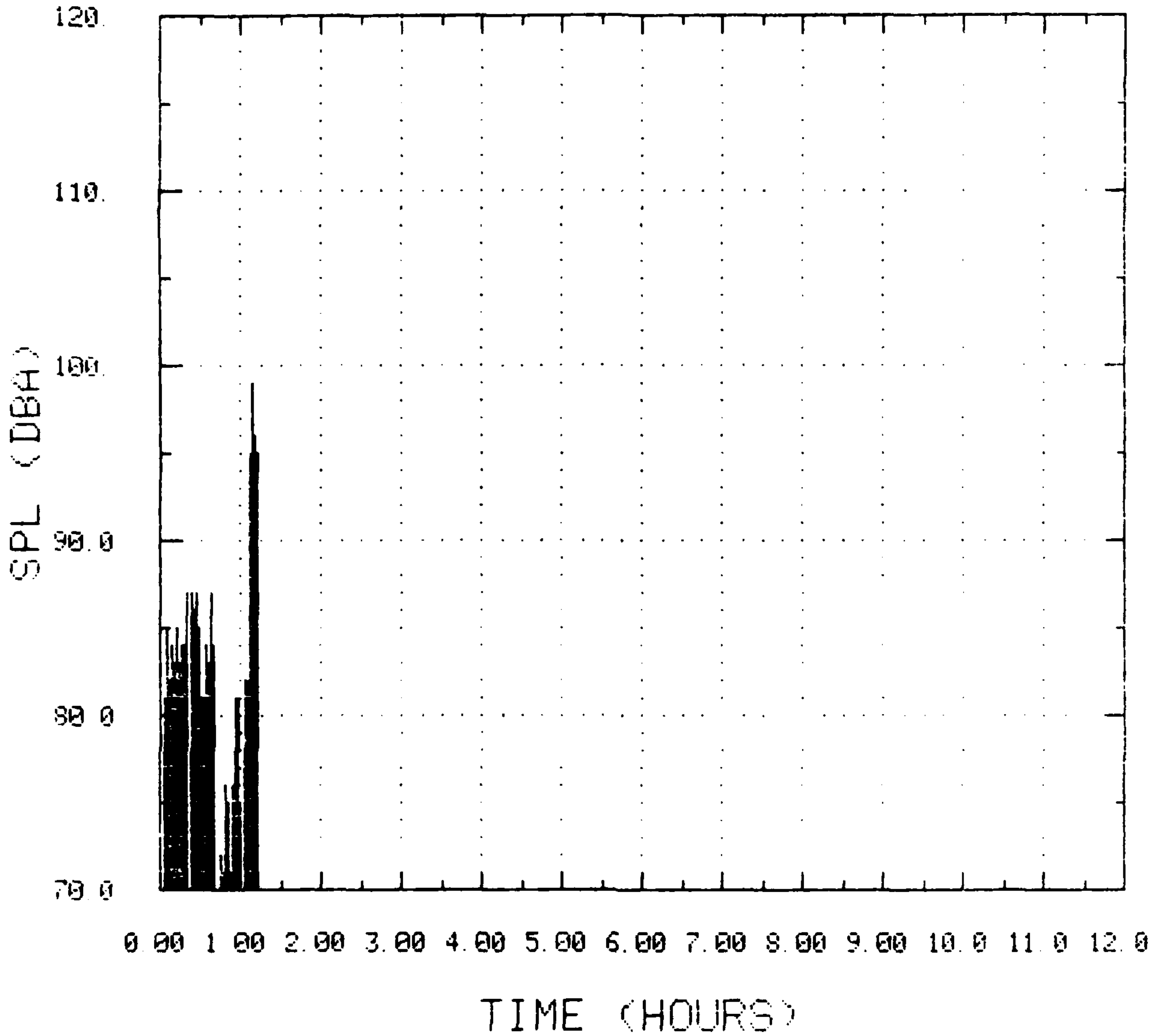

FIGURE B-1. NOISE DOSIMETRY ON SwRI PERSONNEL
(Taken in pump room during loading)
Sample No. TX-1

$$SPL_{PER}(i) = 5 \frac{\text{LOG } (8/T)}{\text{LOG } 2} + 90$$

where

T = exposure time calculated from

$$T = \sum_{i=1}^{m} \Delta t_i$$

A maximum SPL_{PER} of 115 dB(A) was applied based on USCG NVC 12-82. Assuming no hearing protection, the permissible exposure was exceeded if the two curves cross. The 12-hour and 24-hour effective exosures were calculated and are included in each figure. The permissible $L_{eff}(12)$ is 87 dB(A), and the permissible $L_{eff}(24)$ is 82 dB(A).

Finally, the data was presented as a cumulative dose versus SPL. By definition, the permissible dose equals 100% as indicated on each figure. The plots indicate the percentage of the permissible dose due to exposures to SPL's less than or equal to the indicated SPL.

In many cases, the dosimetry records are approximately 4 hours long. This corresponds to one-half of the normal workday for 4-on, 8-off shifts. In areas where the sound pressure level is relatively constant, it is reasonable to assume that the exposure recorded during one shift would be repeated on the next shift. This permits a rough assessment of the overall noise exposure. The noise dosimetry records presented in Figures B-29, B-31, B-34, B-37, B-40, B-43, B-46, B-49, B-52, B-55, and B-58 fall into this category.

Noise dosimetry data collected at-sea is discussed in this appendix. The data was collected using Metrosonic dB-301 Dosimeters programmed for an 80 dB(A) cutoff and a 5 dB exchange rate. During sampling, the microphones from these units were attached to the worker's collar, as close to the ear as possible. The data obtained is presented in three formats to facilitate analysis. The formats include histograms, cumulative effective exposures and cumulative dose.

The histograms presented illustrate the variation of exposures encountered during a particular workday. In conjunction with time-motion studies, exposures can be correlated to specific work activities throughout the day. For engine room personnel, the exposures remained relatively constant throughout a shift. Therefore, time-motion data was not collected with each sample.

Cumulative effective exposures, L_{eff}, were calculated and plotted as a function of time. This calculation is based on a permissible 8-hour exposure of 90 dB(A), a 5 dB exchange rate, and an 80 dB(A) cutoff using the following relationship.

$$L_{eff}(i) = 16.61 \text{ LOG } \frac{1}{\sum\limits_{i=1}^{m} \Delta t_i} \sum_{i=1}^{m} 10^{L_{A_i}/16.61} \Delta t_i$$

where

L_{A_i} = SPL measured during the i-th sample interval

Δt_i = exposure duration during i-th interval

i = time period of interest

A plot of the permissible exposure as a function of time was superimposed on the cumulative effective exposure graphs. The permissible exposure function is described by

APPENDIX B-1

NOISE DOSIMETRY

On the laden voyage, Deck Department employees were monitored for exposure to noise from needle guns that were being used for paint chipping. Two of the employees were directly involved in paint chipping. The third employee was painting in the area where chipping was being conducted. In addition, the Radio Officer was monitored during tank entry to replace a fathometer transponder. The remainder of this section presents the results of these sampling activities.

The safety equipment used by the seamen involved in deck day work varied considerably. Some wore ear muffs, others wore no protective equipment. Table VII.5 indicates the activity, safety equipment, and sample numbers. The noise dosimetry results are presented in Appendix B-1.

TABLE VII.5. SAMPLING DURING DECK DAY WORK

Activity	Noise Dosimetry	Hearing Protectors
Painting	TX-4	None
Chipping	TX-3	Ear muffs*
Chipping/Painting	TX-5	Ear plugs

*Ear muffs manufactured by Fibre-Metal Products, Inc., Noisegard Model 2011; tested in accordance with ANSI S3.19-1974.

While following the Radio Officer during tank entry (forepeak ballast tank), an SwRI employee wore charcoal tube sample TX-106. Subsequent analysis of TX-106 showed 18 ppm THC as hexane and 0.4 ppm benzene. During the tank entry, the oxygen level was 20.8%. The total hydrocarbon concentration in the tank was measured as 30 ppm Methane using an OVA. In addition, a colorimetric tube for measuring the concentration of CO did not show any measurable stain length. At the time of these measurements the temperature in the tank was 89°F dry bulb and 80°F wet bulb.

TABLE VII.3. OVA SURVEY RESULTS - BOTTOM OF PUMP ROOM (Day 3)

Location ID	Concentration (ppm)
A	25
B	25
C	25
D	25
E	25
F	30
G	30
H	25
I	26
J	25
K	26
L	24
M	26
N	24
O	25
P	30

TABLE VII.4. OVA SURVEY RESULTS - BOTTOM OF PUMP ROOM (Day 9)

Location ID	Concentration (ppm)
A	26
B	25
C	20-25
D	34
E	35
F	100
G	20
H	20
I	20

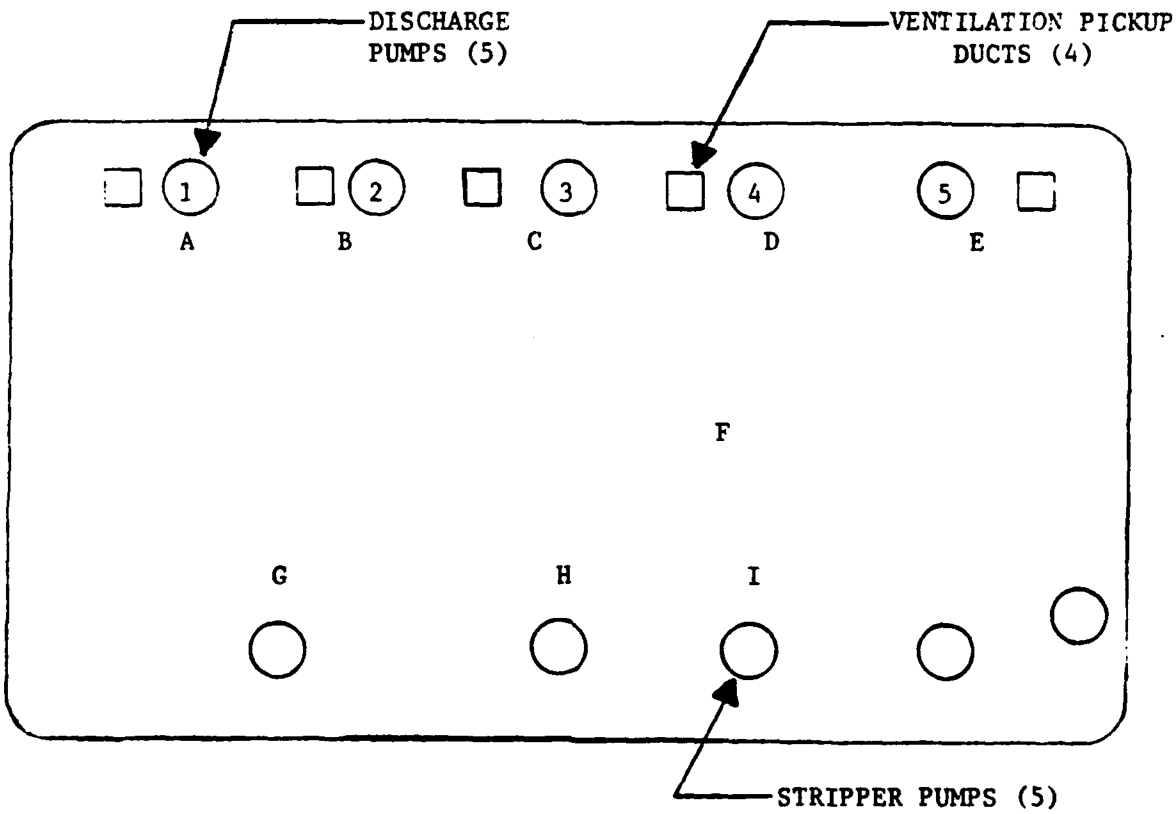

FIG. VII.4. OVA SURVEY POINTS - BOTTOM OF PUMP ROOM (Day 9)

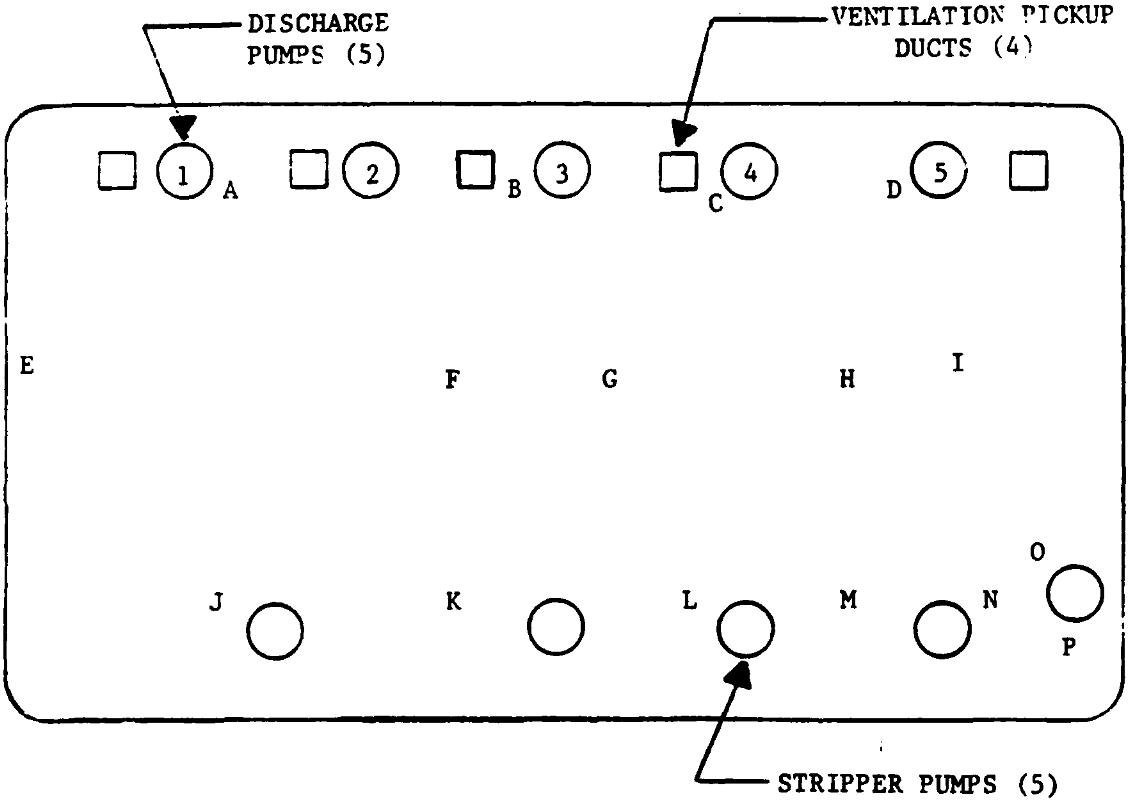

FIGURE VII.3. OVA SURVEY POINTS - BOTTOM OF PUMP ROOM (Day 3)

TABLE VII.2. OVA SURVEY RESULTS - SHAFT LEVEL OF ENGINE ROOM

Location ID	Concentration* (ppm)	
	Survey I	Survey II
A	19	14
B	19	14
C	19	15
D	19	14
E	20	14
F	19	14
G	17	14
H	18	14
I	18	14
J	17	14
K	17	14
L	17	15
M	18	14
N	17	15
O	18	15
P	17	16
Q	18	15
R	18	16

*I. Survey conducted at loading terminal.
II. Survey conducted while underway.

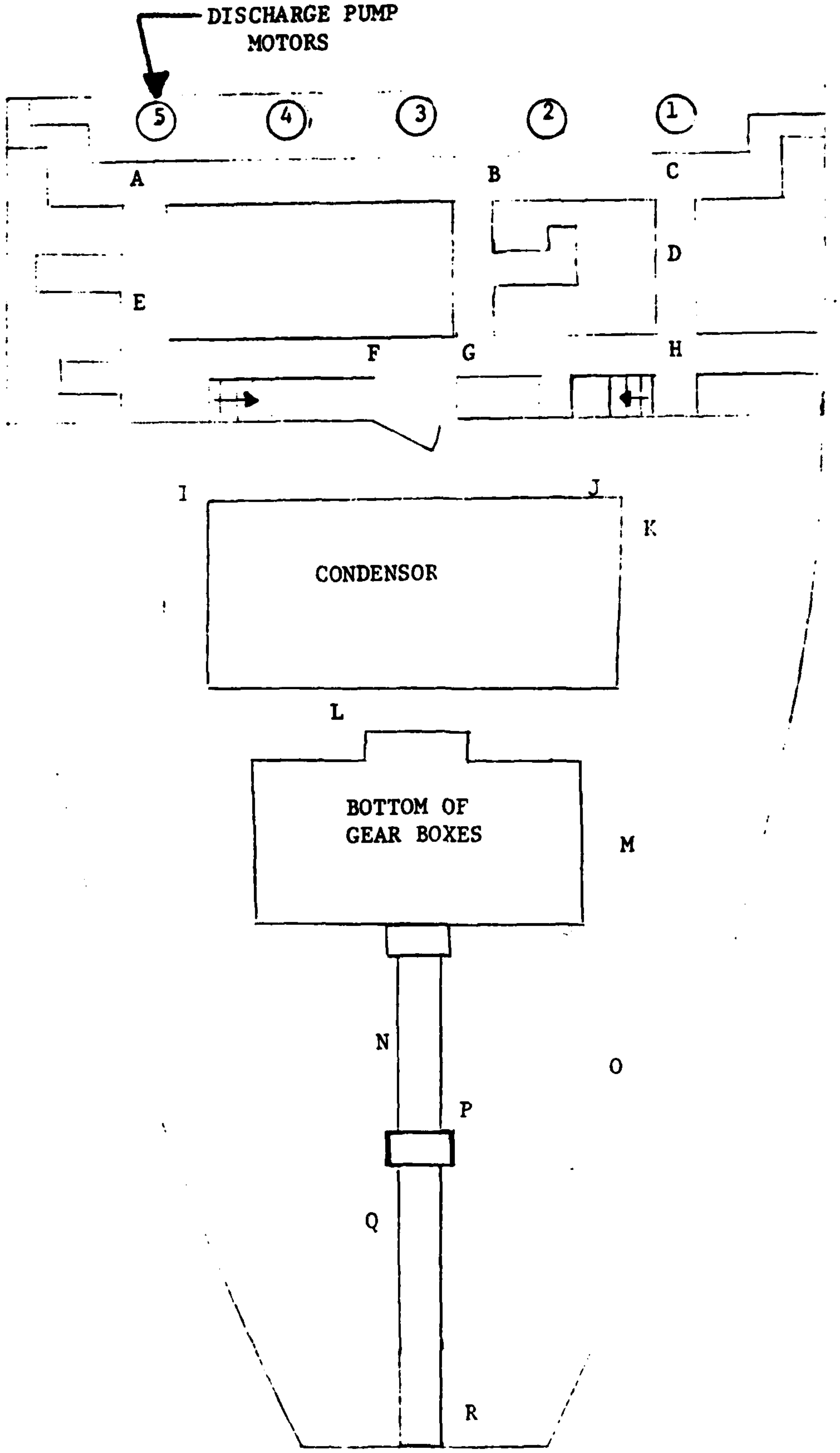

FIGURE VII.2. OVA SURVEY POINTS - SHAFT LEVEL OF ENGINE ROOM

TABLE VII.1. OVA SURVEY RESULTS - CONTROL ROOM AND FIRE ROOM

Location ID	Concentration* (ppm)	
	Survey I	Survey II
A	15	14
B	15	--
C	15	14
D	16	14
E	15	15
F	15	12
G	15	15
H	15	12
I	34	44
J	12	12
K	12	11
L	12	11
M	14	12
N	11	--
O	15	12
P	15	13
Q	15	13
R	13	14
S	15	14
T	13	13

*I. Survey conducted at loading terminal.
II. Survey conducted while underway.

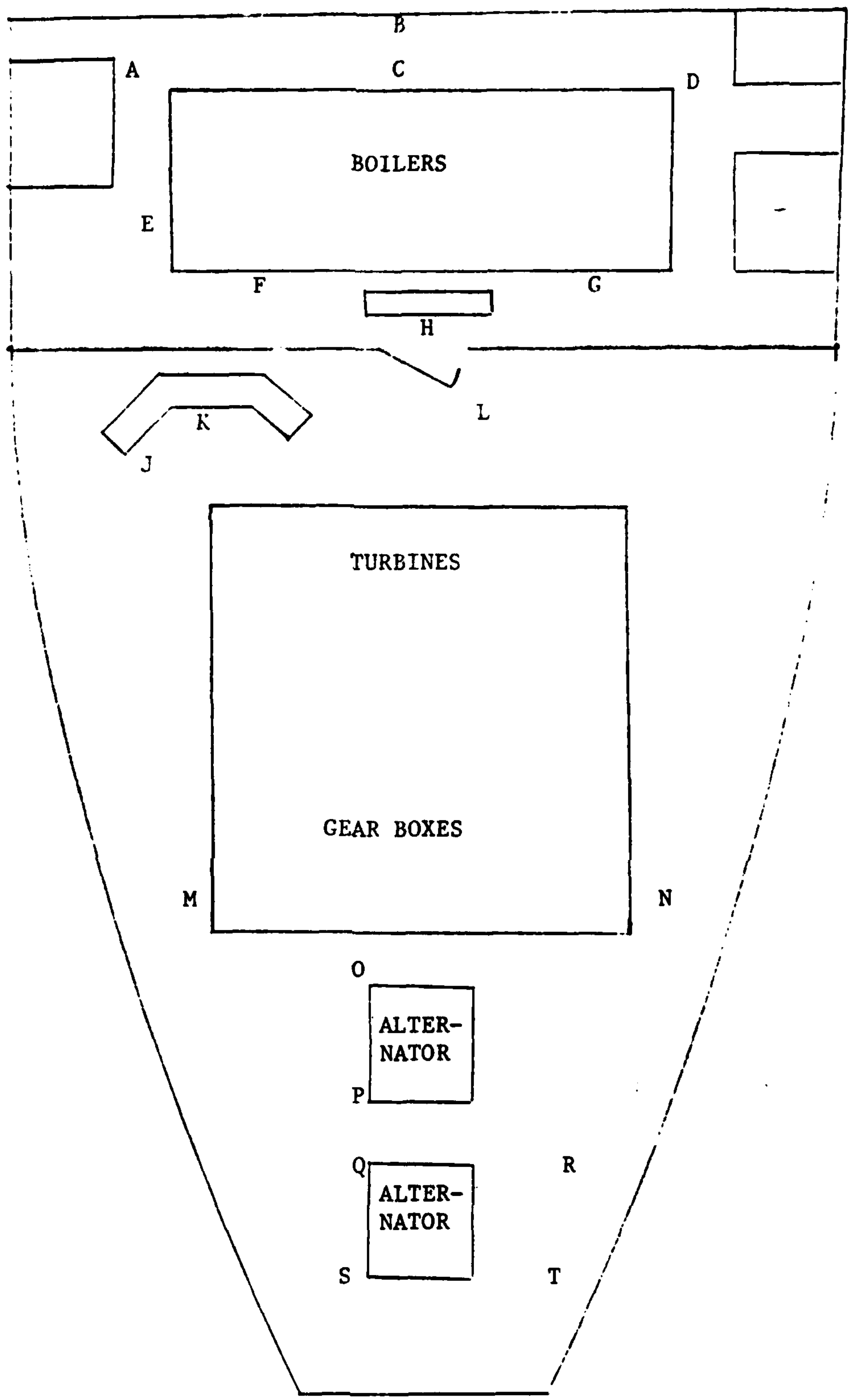

FIGURE VII.1. OVA SURVEY POINTS - CONTROL ROOM AND FIRE ROOM

VII. Miscellaneous

This section presents the results of OVA surveys and sampling during deck activities such as chipping and painting. Figure VII.1 shows the OVA survey points in the Engine Control Room and Fire Room. The levels measured at these points during loading and at-sea are presented in Table VII.1. Location I in Figure VII.1 corresponds to the fireman's work station where burner tips are quenched in a bath of fuel oil treatment. Figure VII.2 and Table VII.2 provide the same information for measurements taken in the shaft level of the Engine Room.

Similarly, two surveys were conducted in the Pump Room. One was conducted during loading and the other was conducted during discharge. At the time of the first survey, the following readings were obtained:

- o 17 ppm on the top level
- o 18 ppm one level down
- o 19 ppm two levels down
- o 20 ppm three levels down

The points surveyed at the bottom of the Pump Room are indicated in Figure VII.3. The results are shown in Table VII.3. At the bottom of the pump room, wet bulb and dry bulb temperatures were 82°F and 97°F, respectively.

At the time of the second survey, the following readings were obtained:

- o 25 ppm at the top
- o 27 ppm one level down
- o 27 ppm two levels down
- o 28 ppm three levels down

Figure VII.4 shows the location of measurements taken on the bottom level of the pump room. Table VII.4 indicates the concentrations recorded at these points.

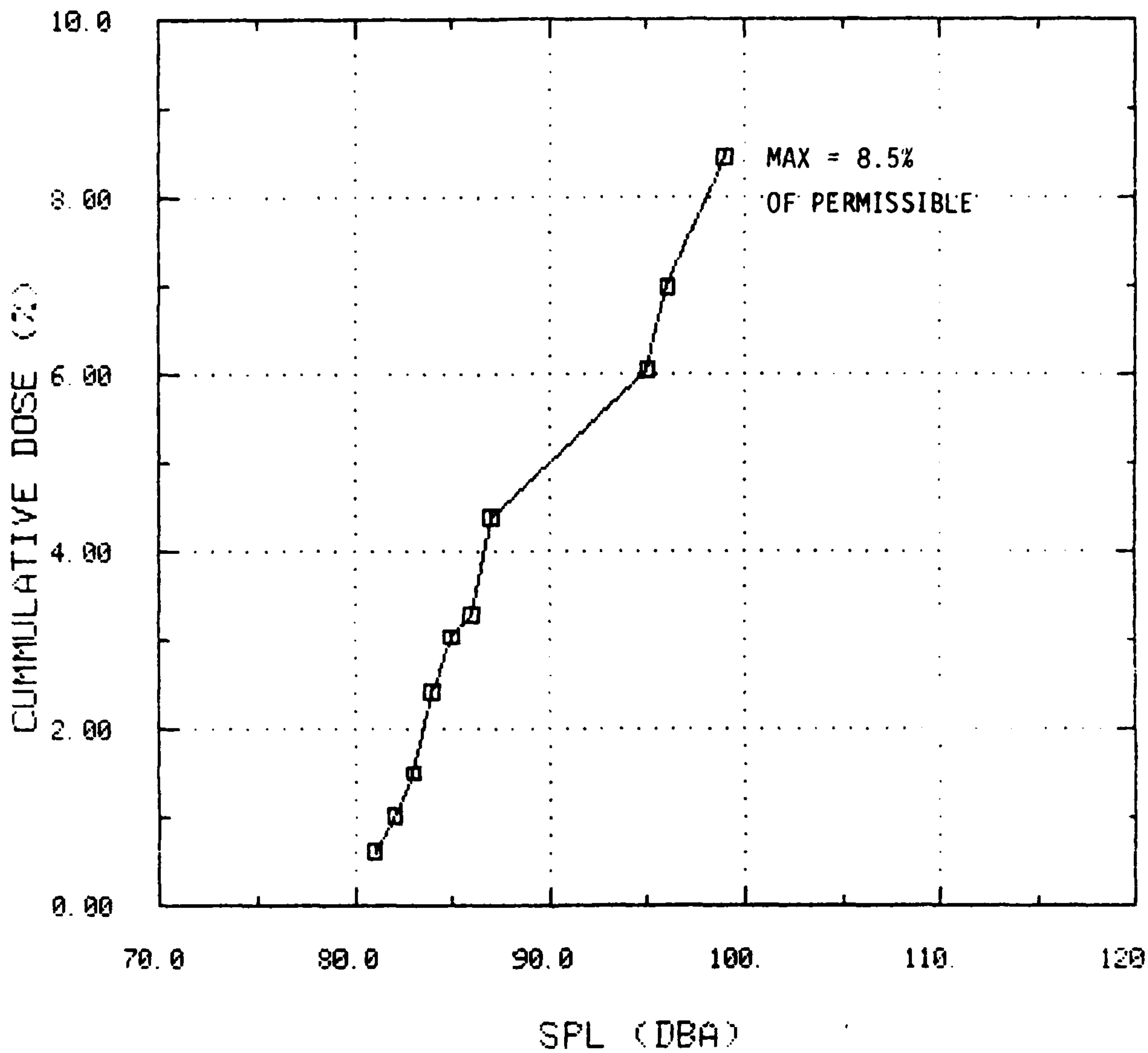

FIGURE B-3. **CUMULATIVE DOSE RECORDED ON SwRI PERSONNEL Sample No. TX-1**

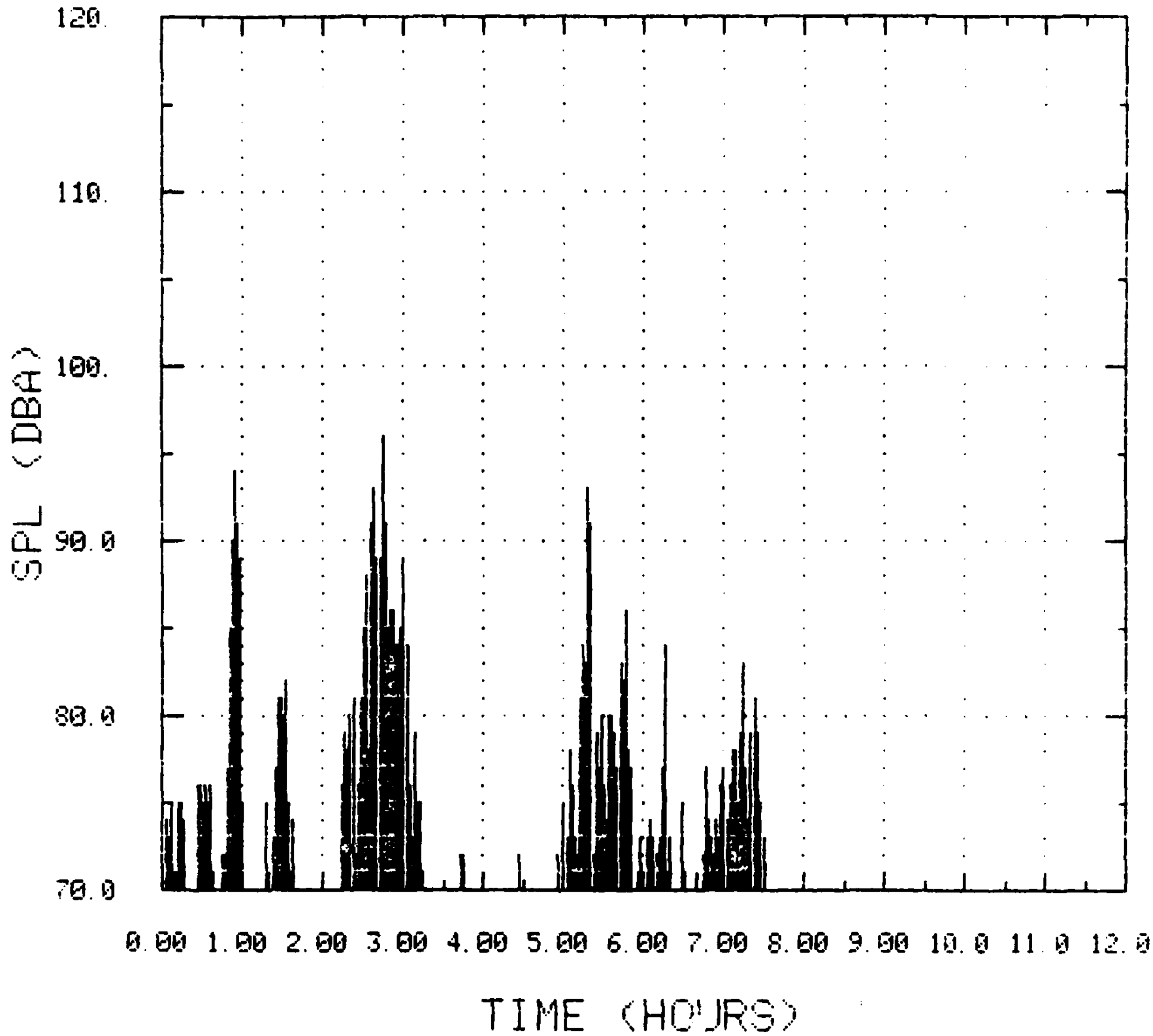

FIGURE B-4. NOISE DOSIMETRY ON SwRI PERSONNEL
(Taken during loading while accompanying pumpman)
Sample No. TX-2

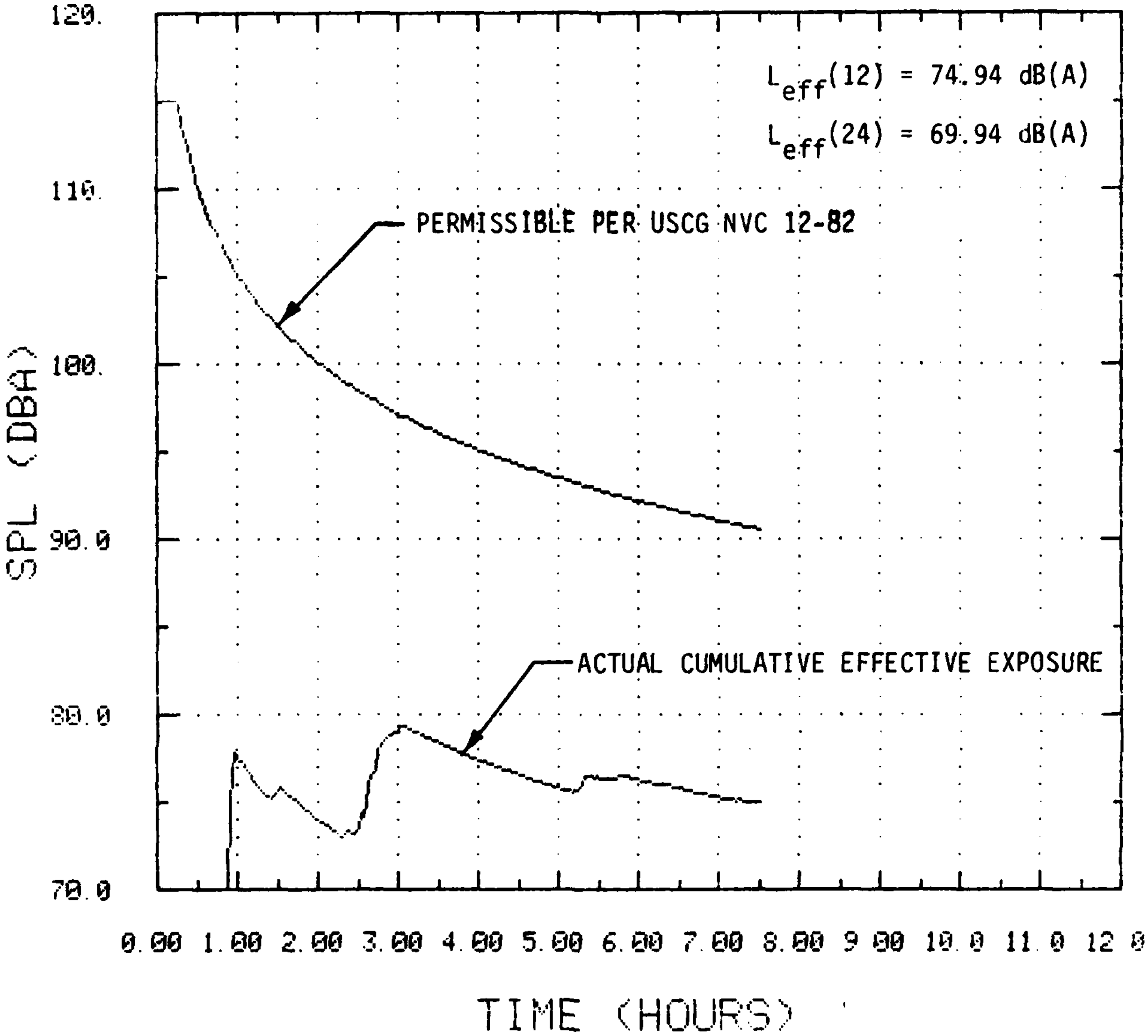

FIGURE B-5. **CUMULATIVE EFFECTIVE EXPOSURE ON SwRI PERSONNEL**
Sample No. TX-2

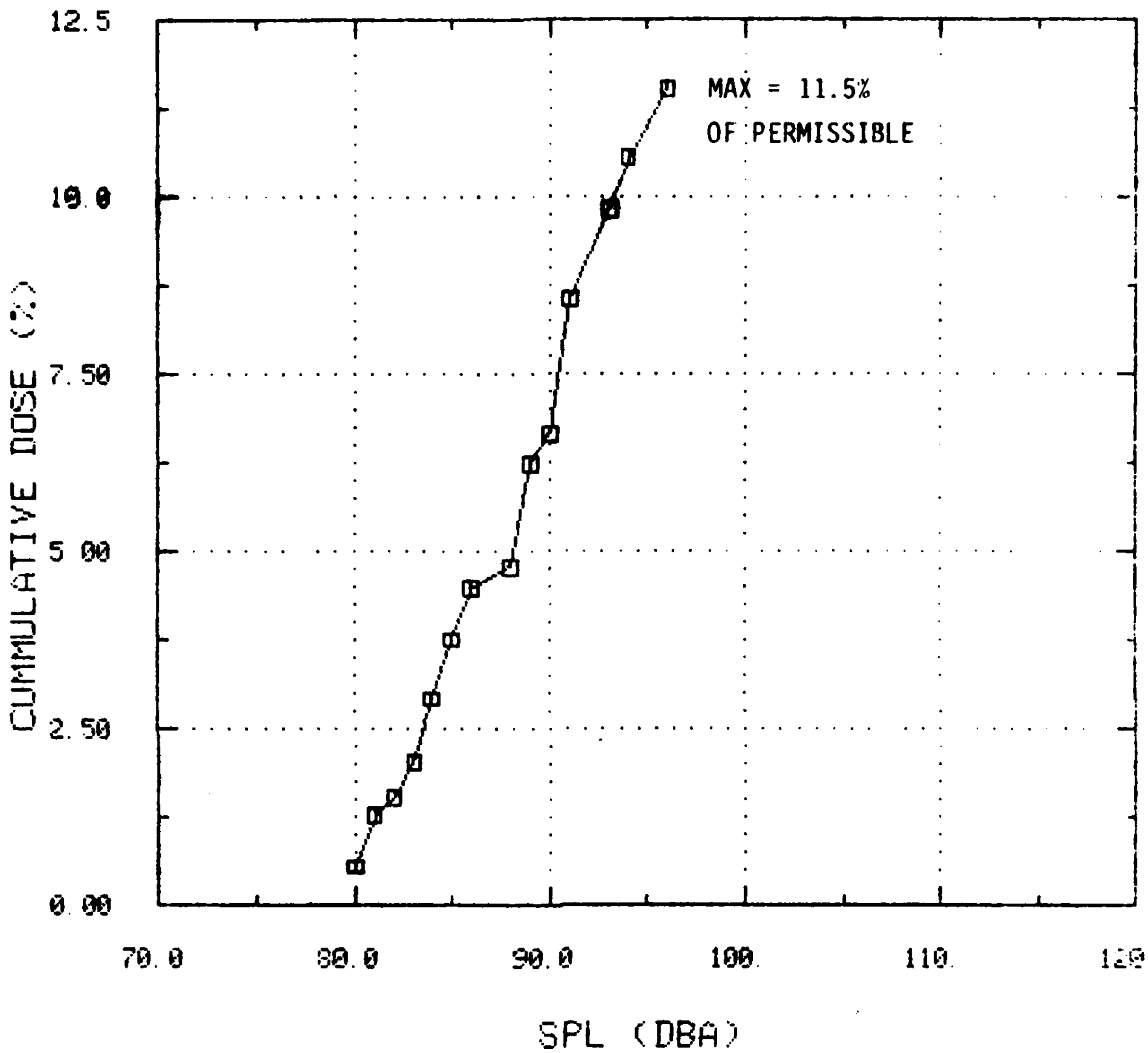

FIGURE B-6. **CUMULATIVE DOSE RECORDED ON SwRI apersonnel Sample No. TX-2**

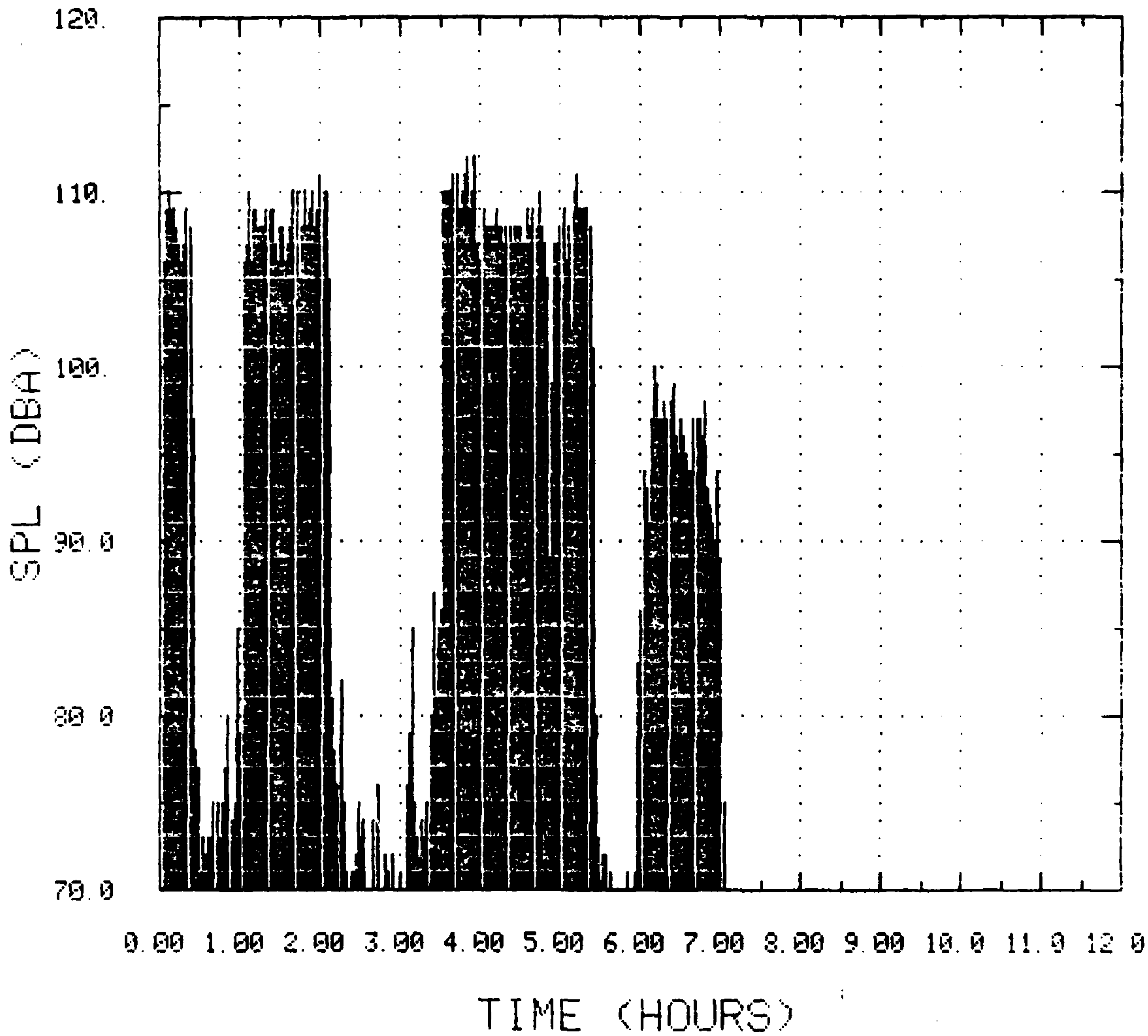

FIGURE B-7. NOISE DOSIMETRY ON SEAMAN
(Taken during laden voyage
while chipping paint)
Sample No. TX-3

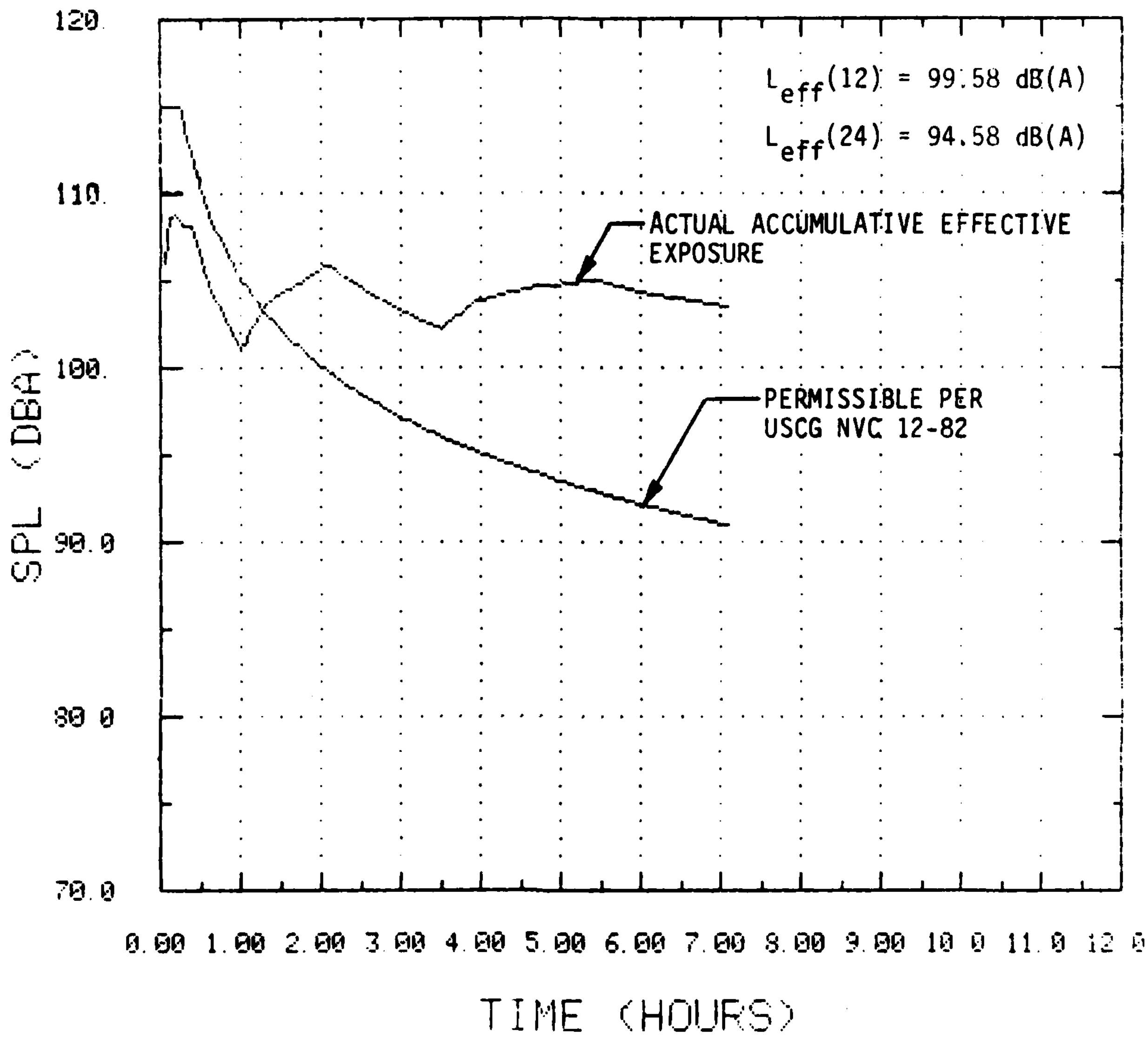

FIGURE B-8. **CUMULATIVE EFFECTIVE EXPOSURE ON SEAMAN**
Sample No. TX-3

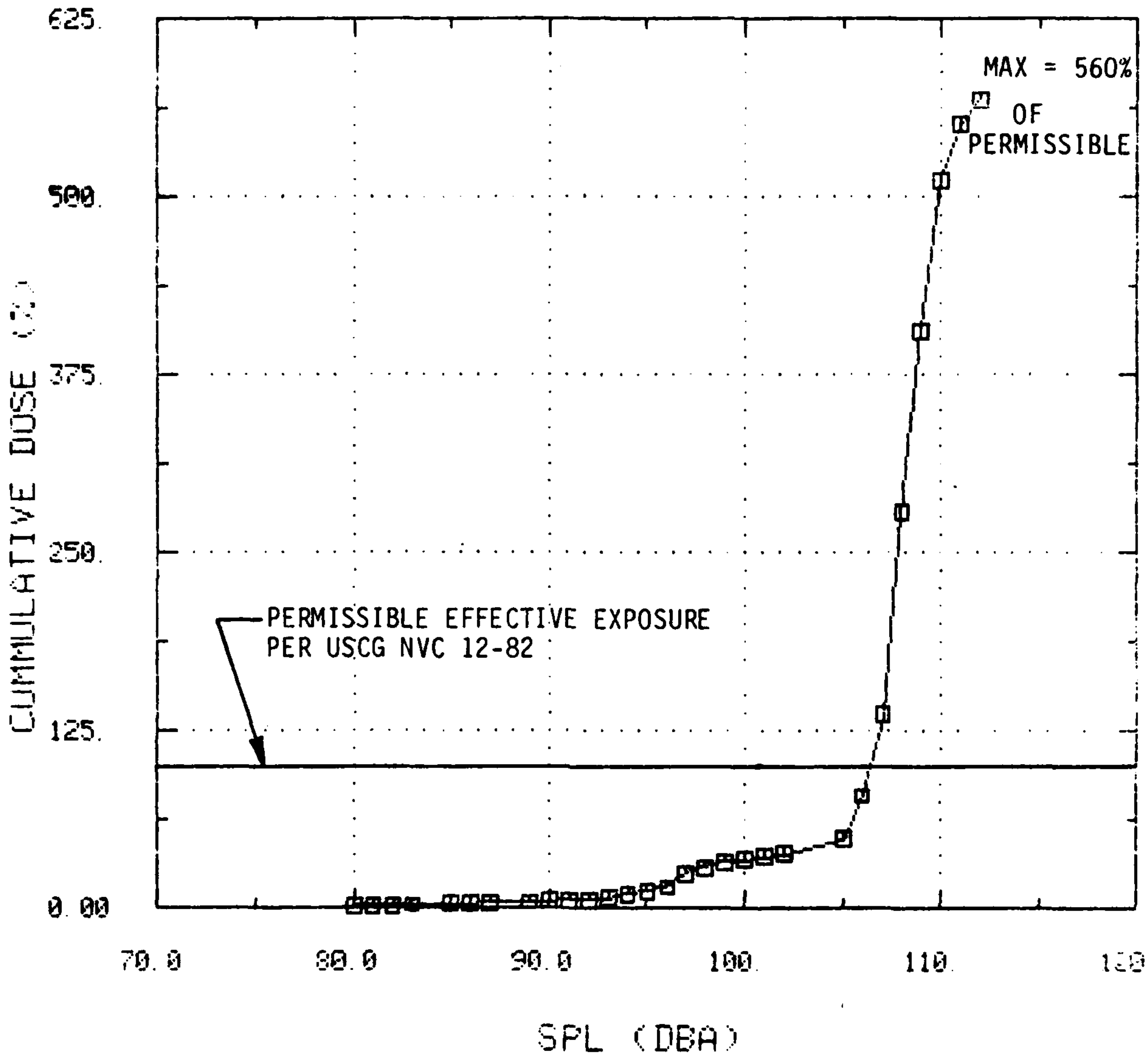

FIGURE B-9. **CUMULATIVE DOSE RECORDED ON SEAMAN**
Sample No. TX-3

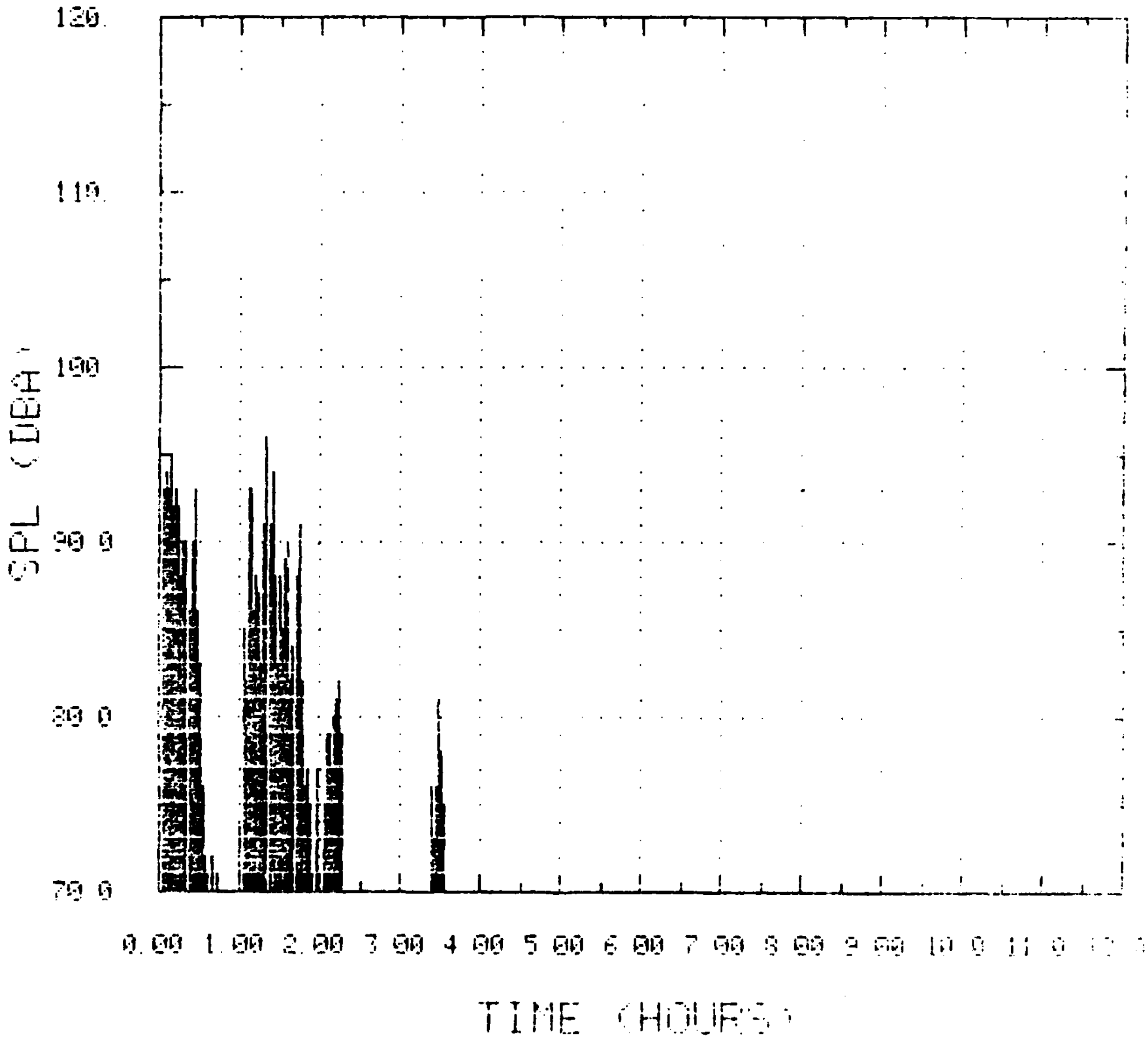

FIGURE B-10. NOISE DOSIMETRY ON SEAMAN
(Taken during laden voyage
while chipping paint)
Sample No. TX-4

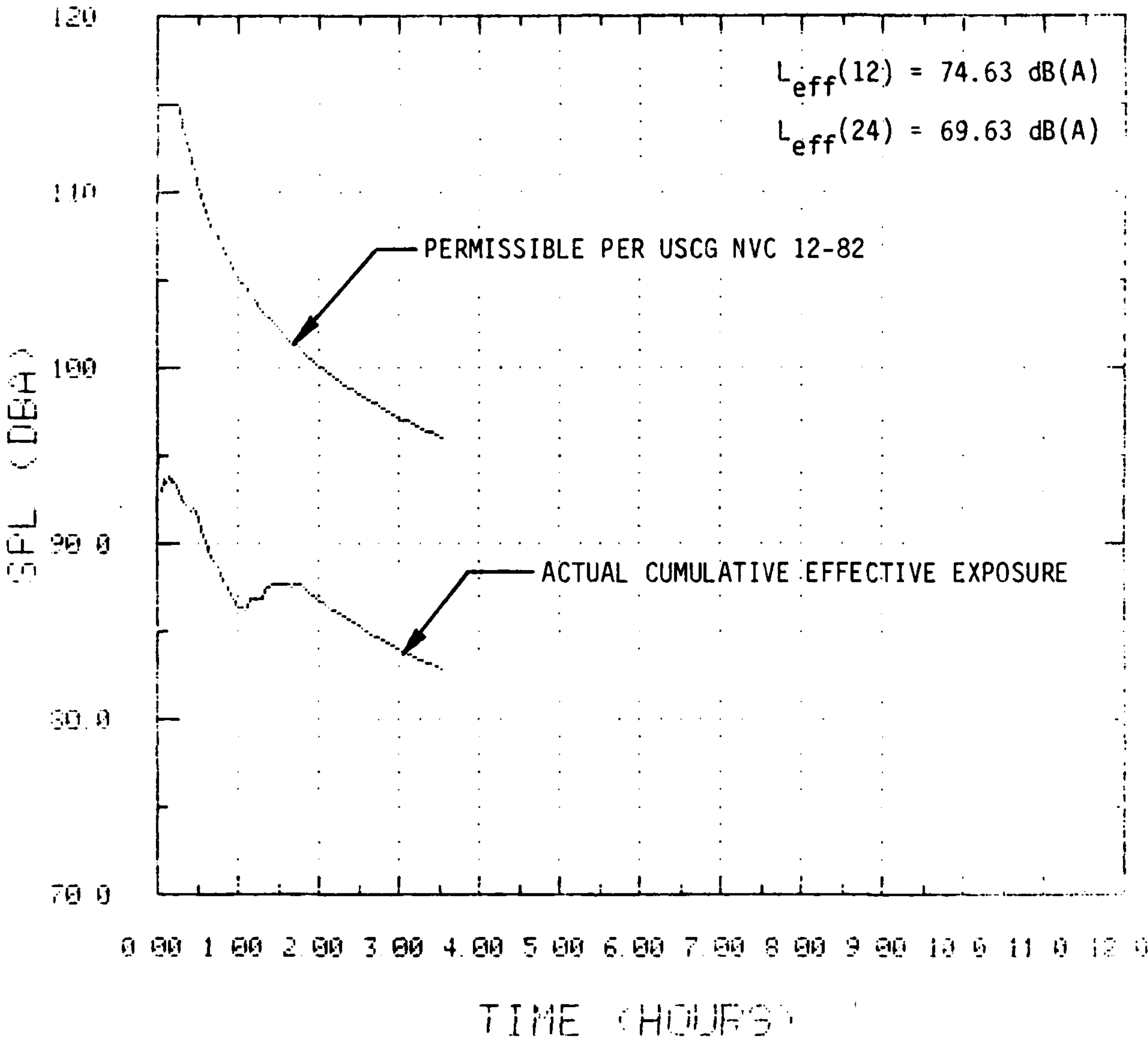

FIGURE B-11. **CUMULATIVE EFFECTIVE EXPOSURE ON SEAMAN Sample No. TX-4**

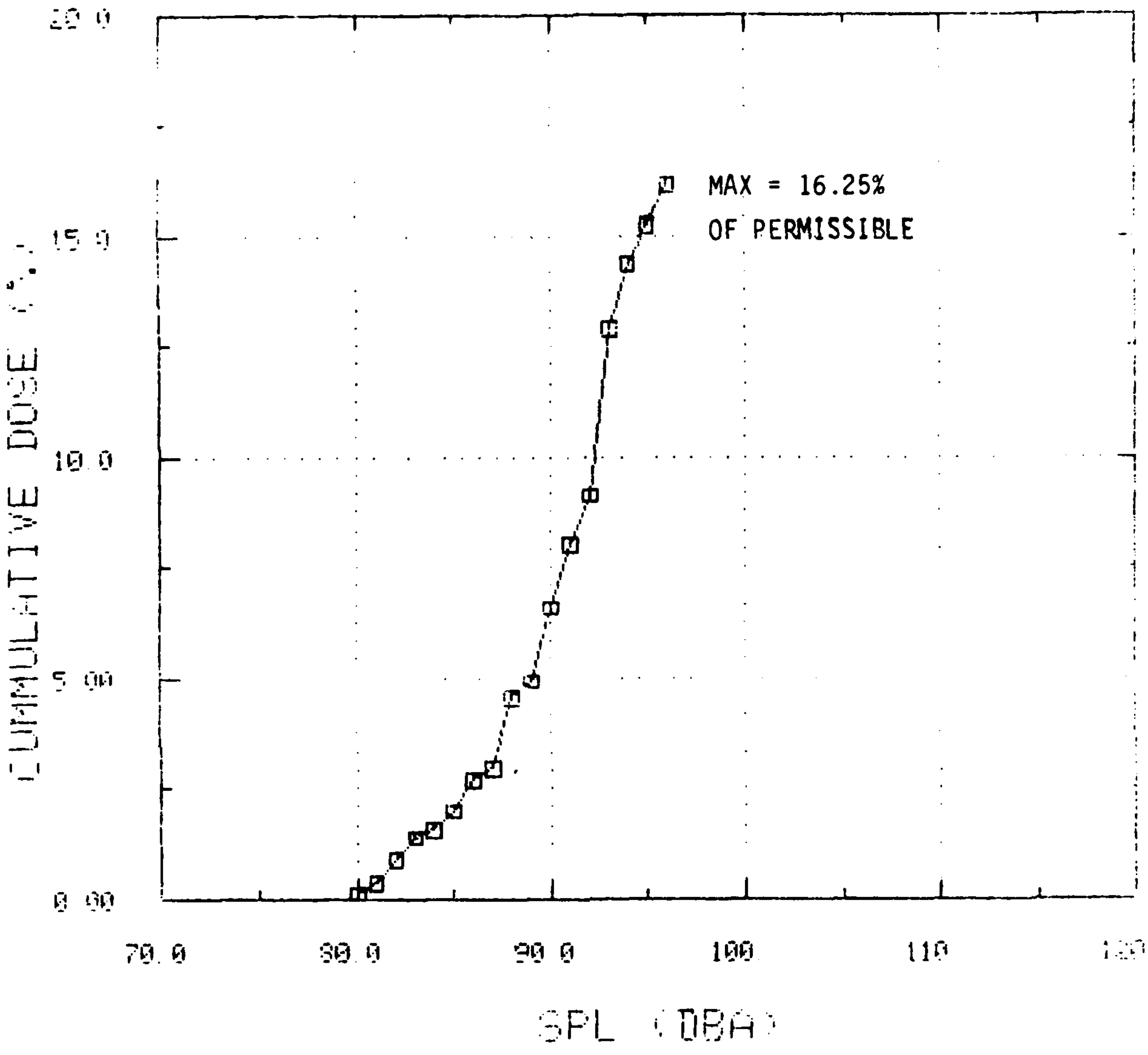

FIGURE B-12. **CUMULATIVE DOSE RECORDED ON SEAMAN**
Sample No. TX-4

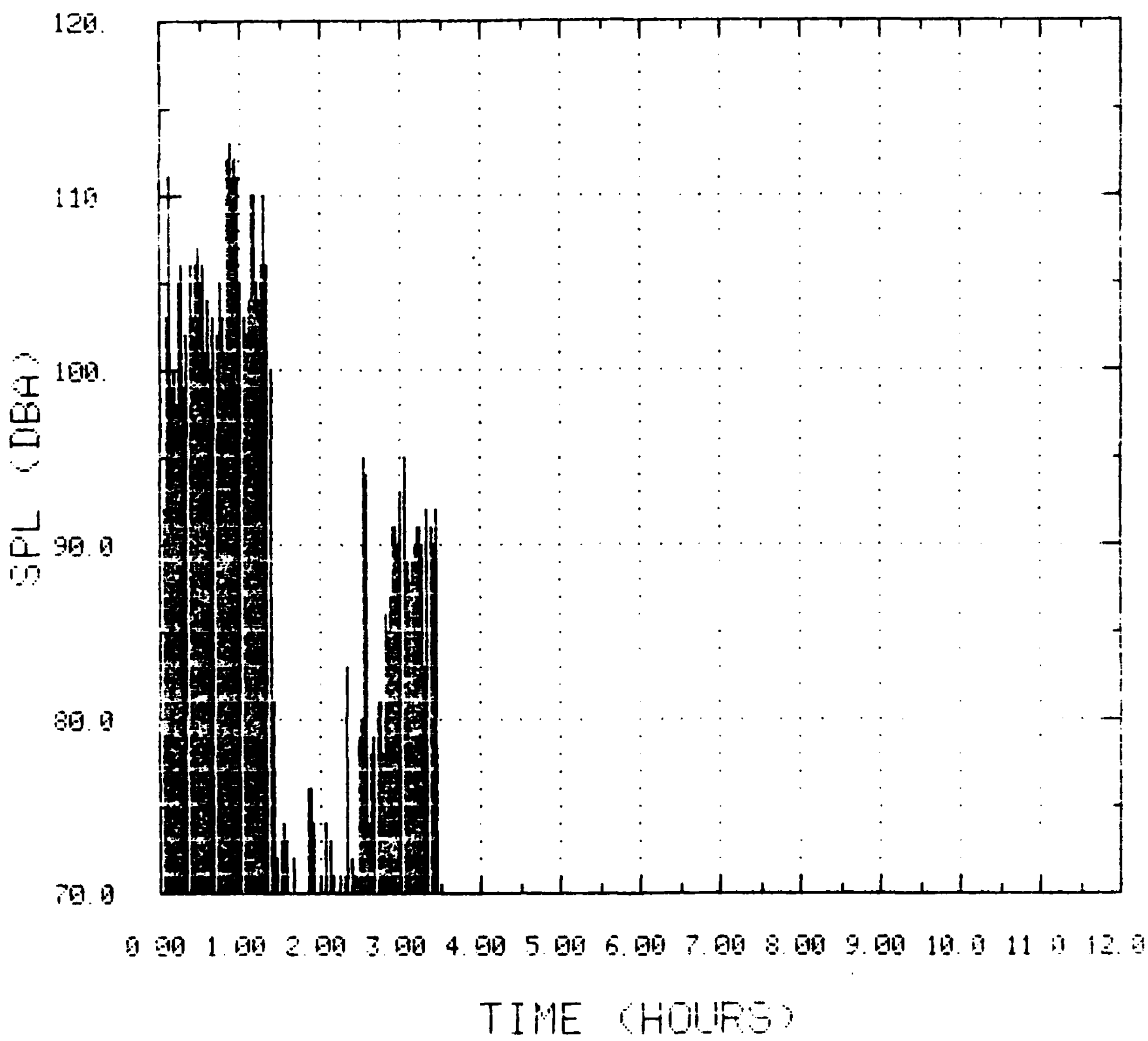

FIGURE B-13. NOISE DOSIMETRY AND SEAMAN
(Taken during laden voyage
while chipping paint)
Sample No. TX-5

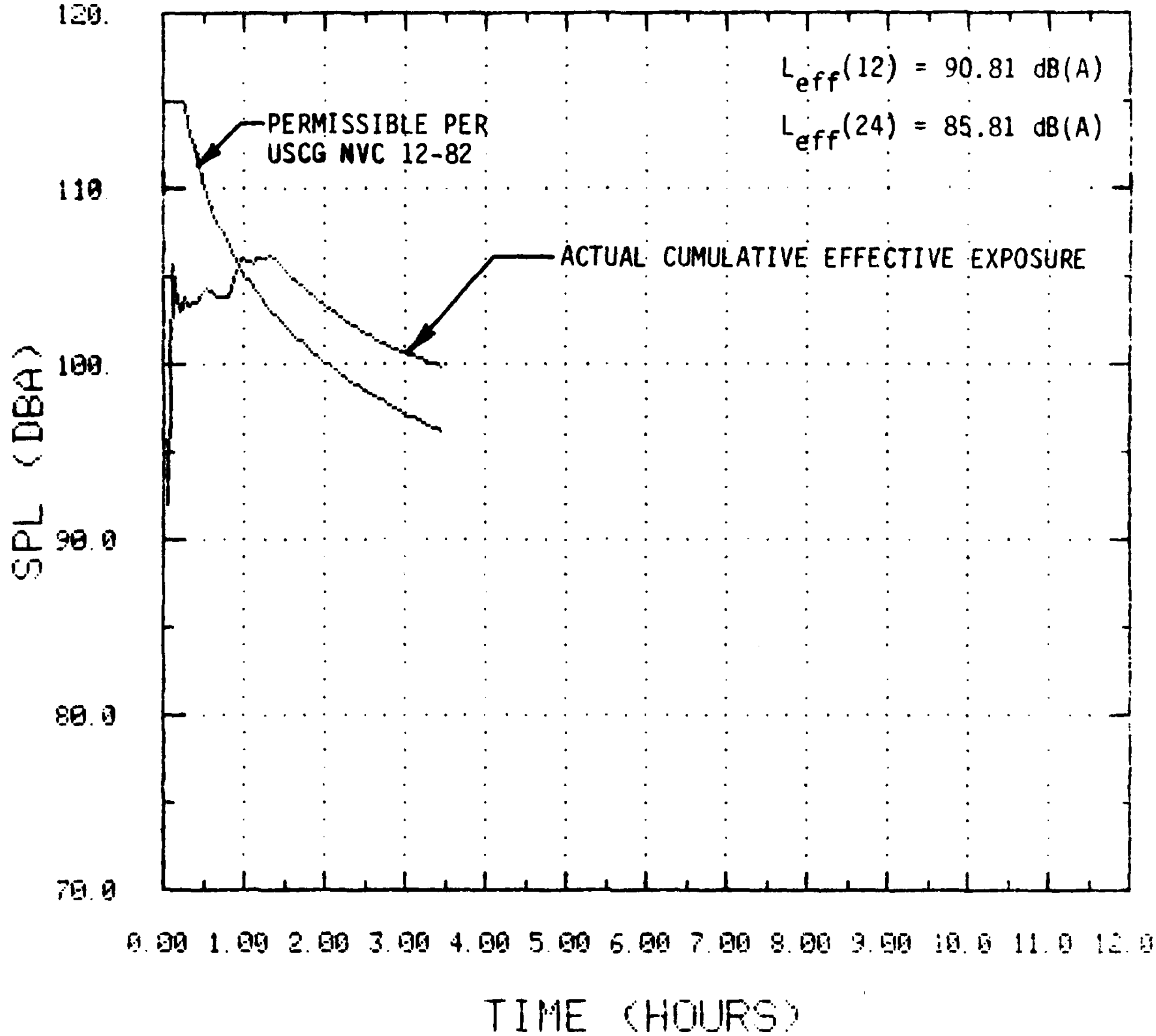

FIGURE B-14. CUMULATIVE EFFECTIVE EXPOSURE ON SEAMAN
Sample No. TX-5

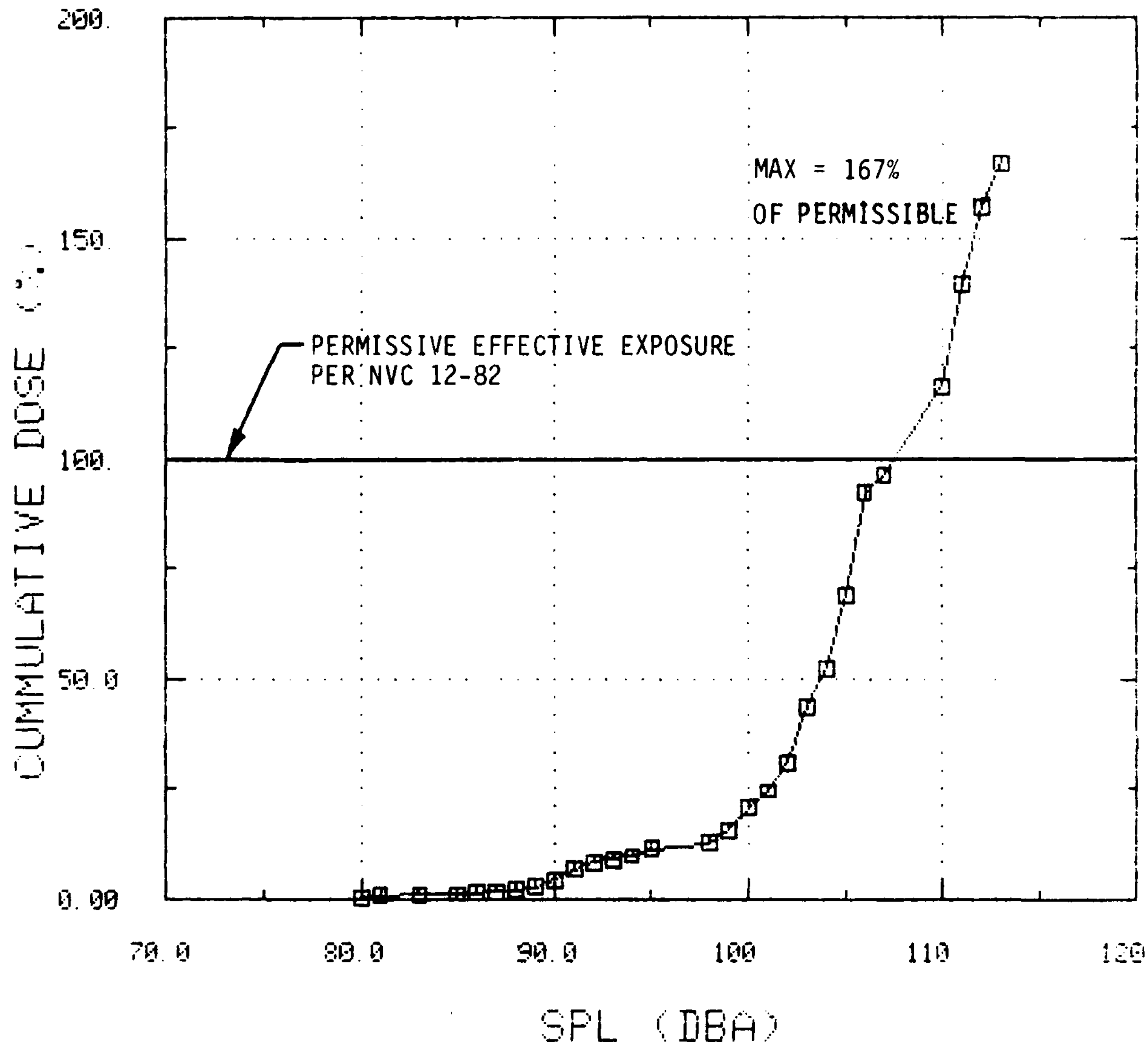

FIGURE B-15. CUMULATIVE DOSE RECORDED ON SEAMAN
Sample No. TX-5

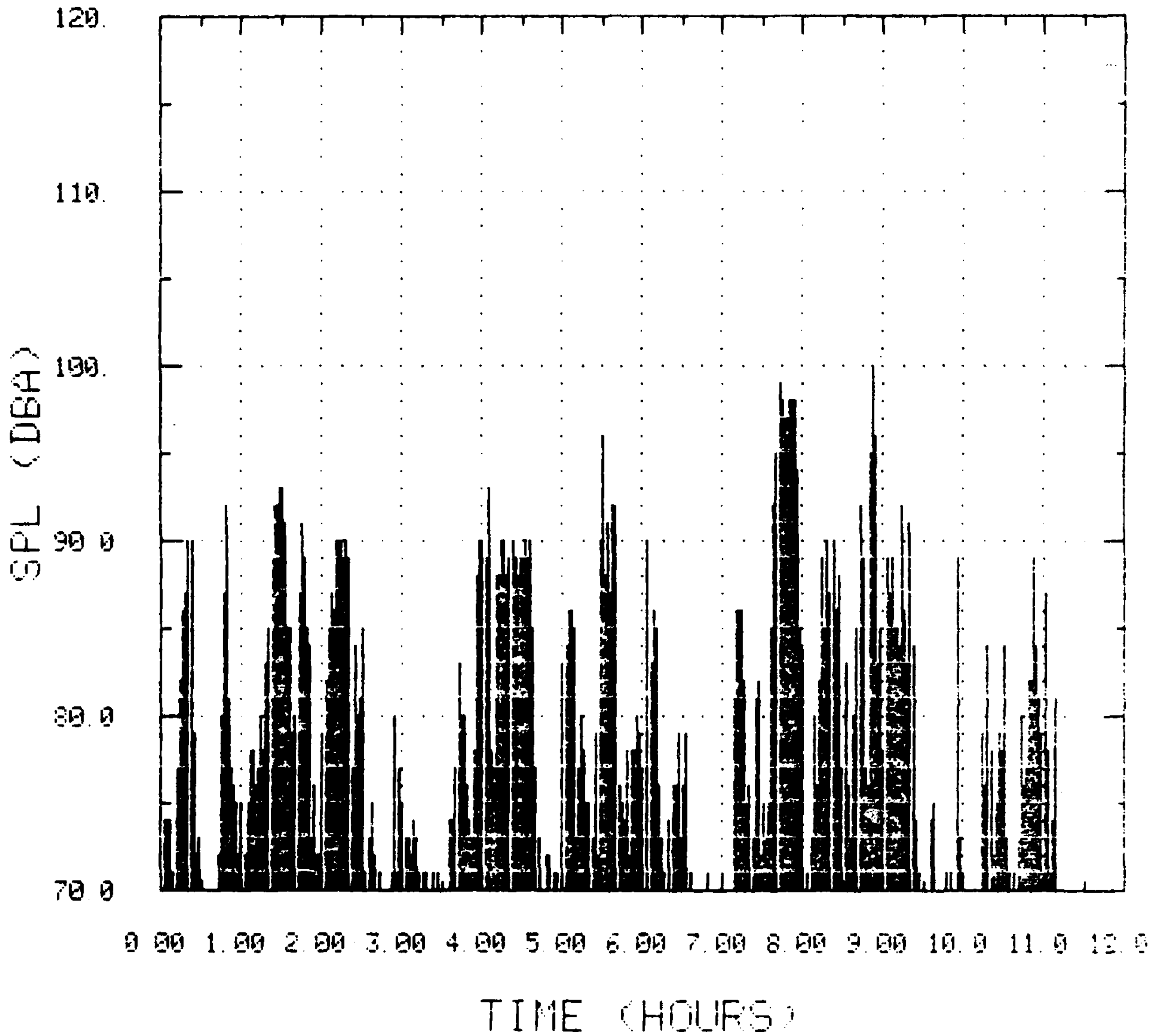

FIGURE B-16. NOISE DOSIMETRY ON SwRI PERSONNEL
(Taken during discharge while accompanying pumpman)
Sample No. TX-6

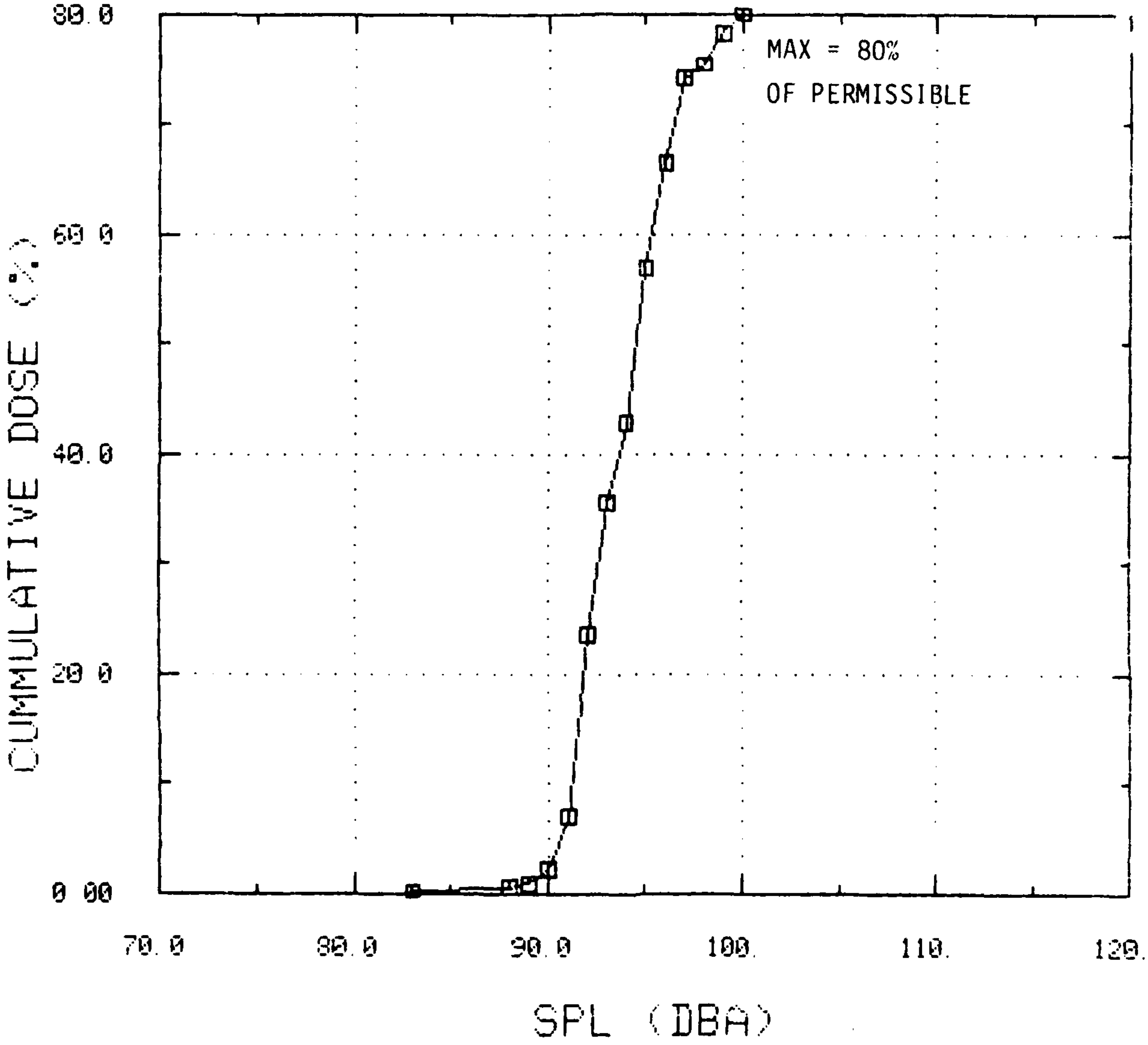

FIGURE B-30. **CUMULATIVE DOSE RECORDED ON SwRI PERSONNEL**
Sample No. TX-10

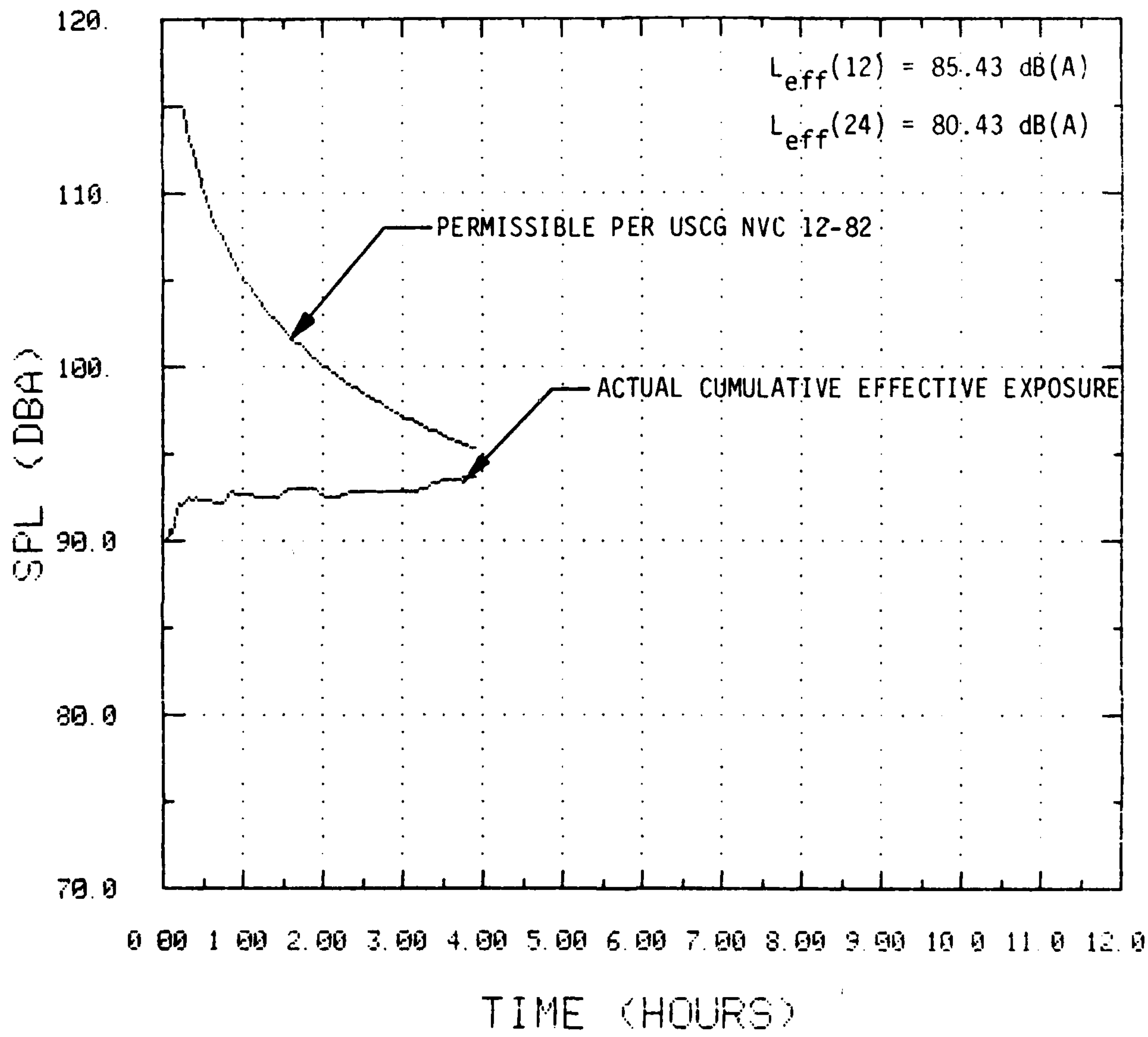

FIGURE B-29. **CUMULATIVE EFFECTIVE EXPOSURE ON SwRI PERSONNEL Sample No. TX-10**

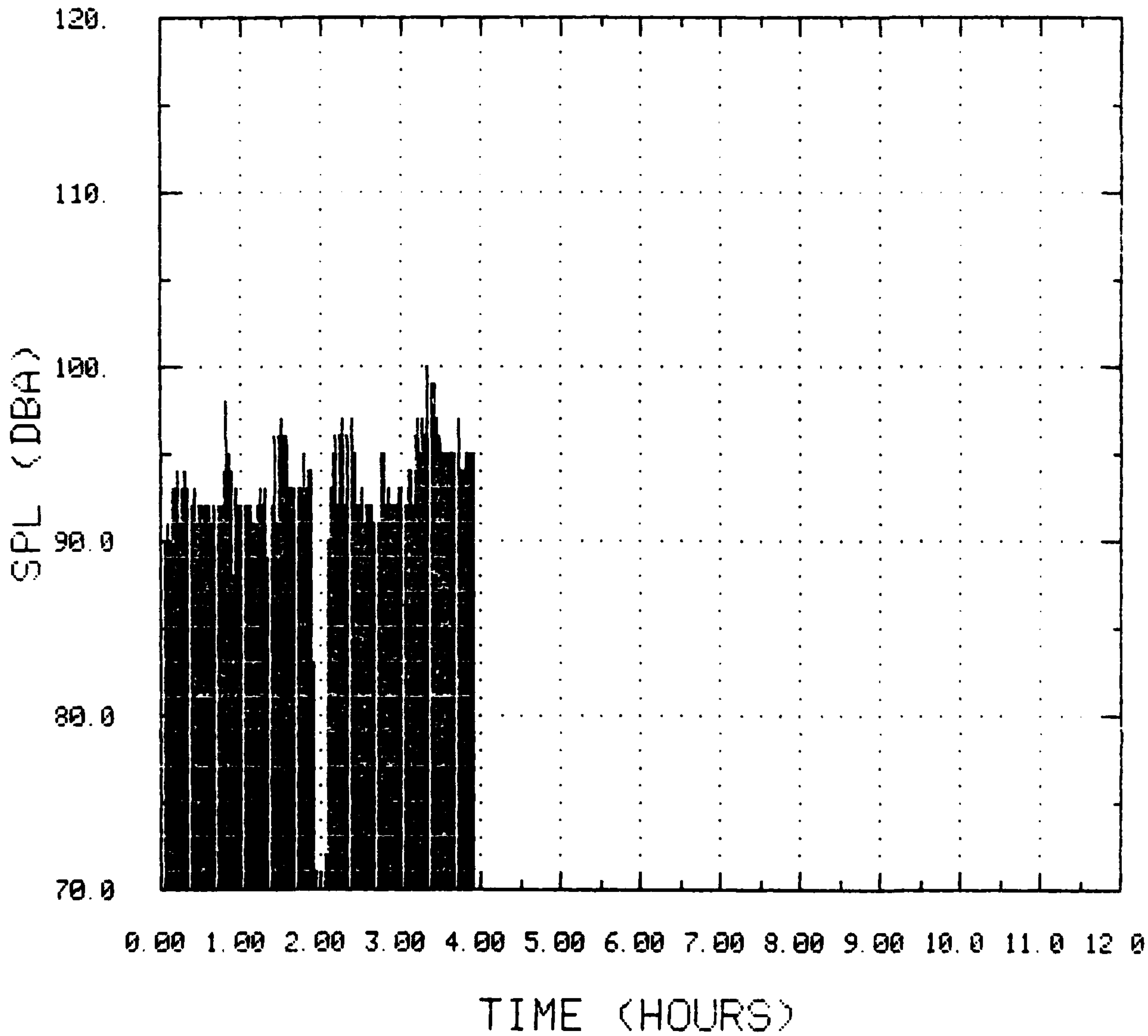

FIGURE B-28. **NOISE DOSIMETRY ON SwRI PERSONNEL (Taken during laden voyage while accompanying oiler) Sample No. TX-10**

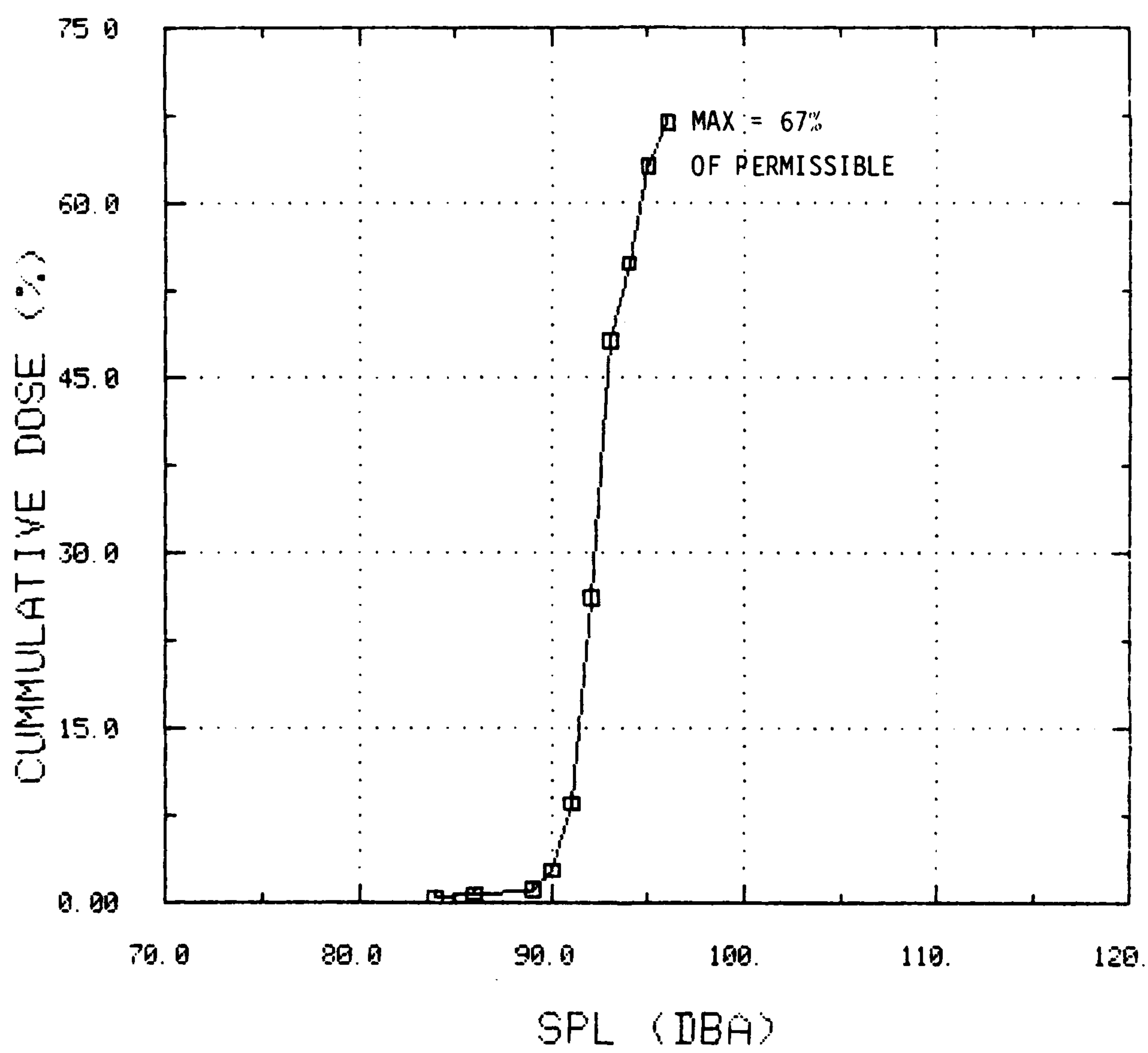

FIGURE B-27. **CUMULATIVE DOSE RECORDED ON SwRI PERSONNEL**
Sample No. TX-9

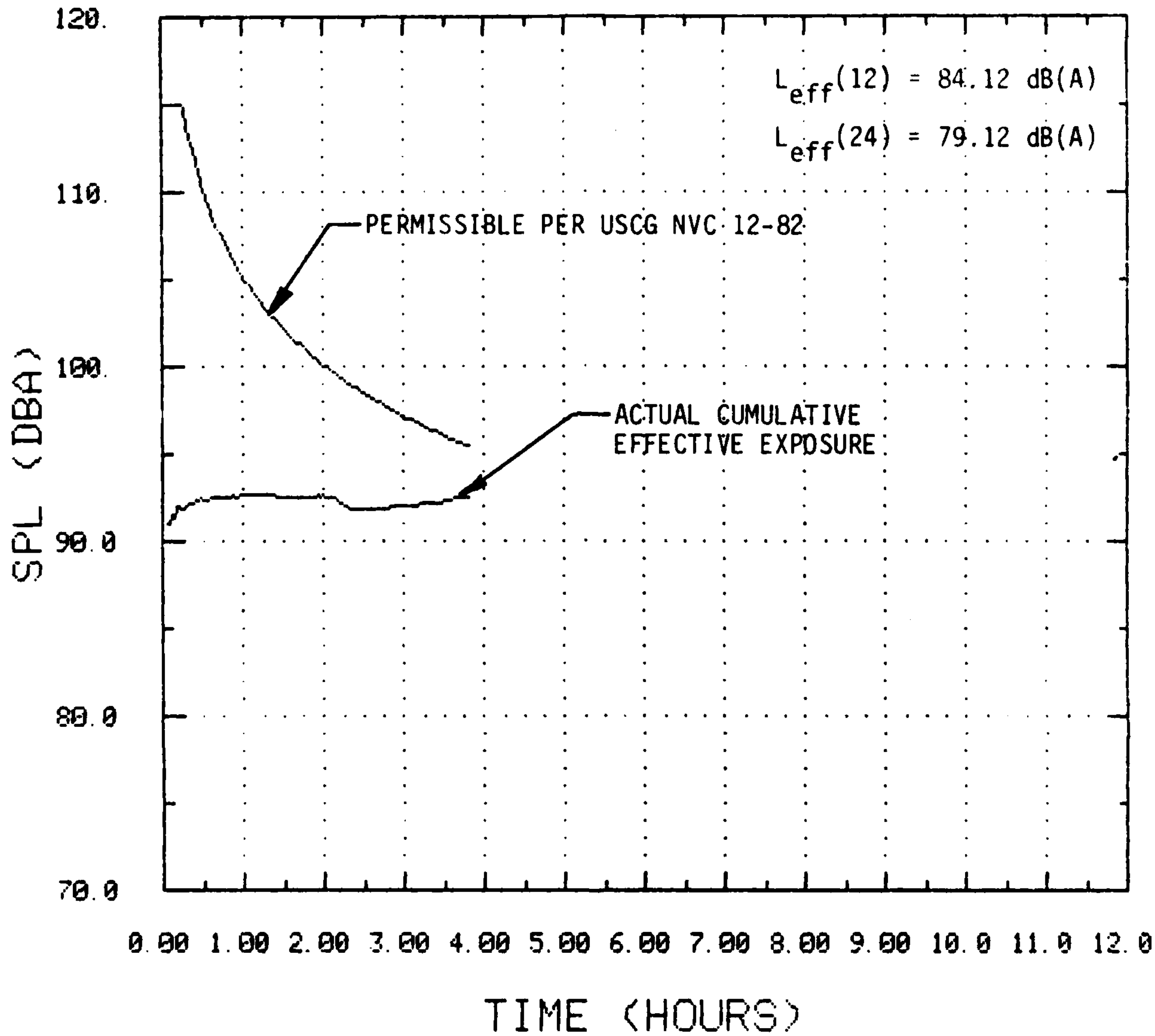

FIGURE B-26. **CUMULATIVE EFFECTIVE EXPOSURE ON SwRI PERSONNEL Sample No. TX-9**

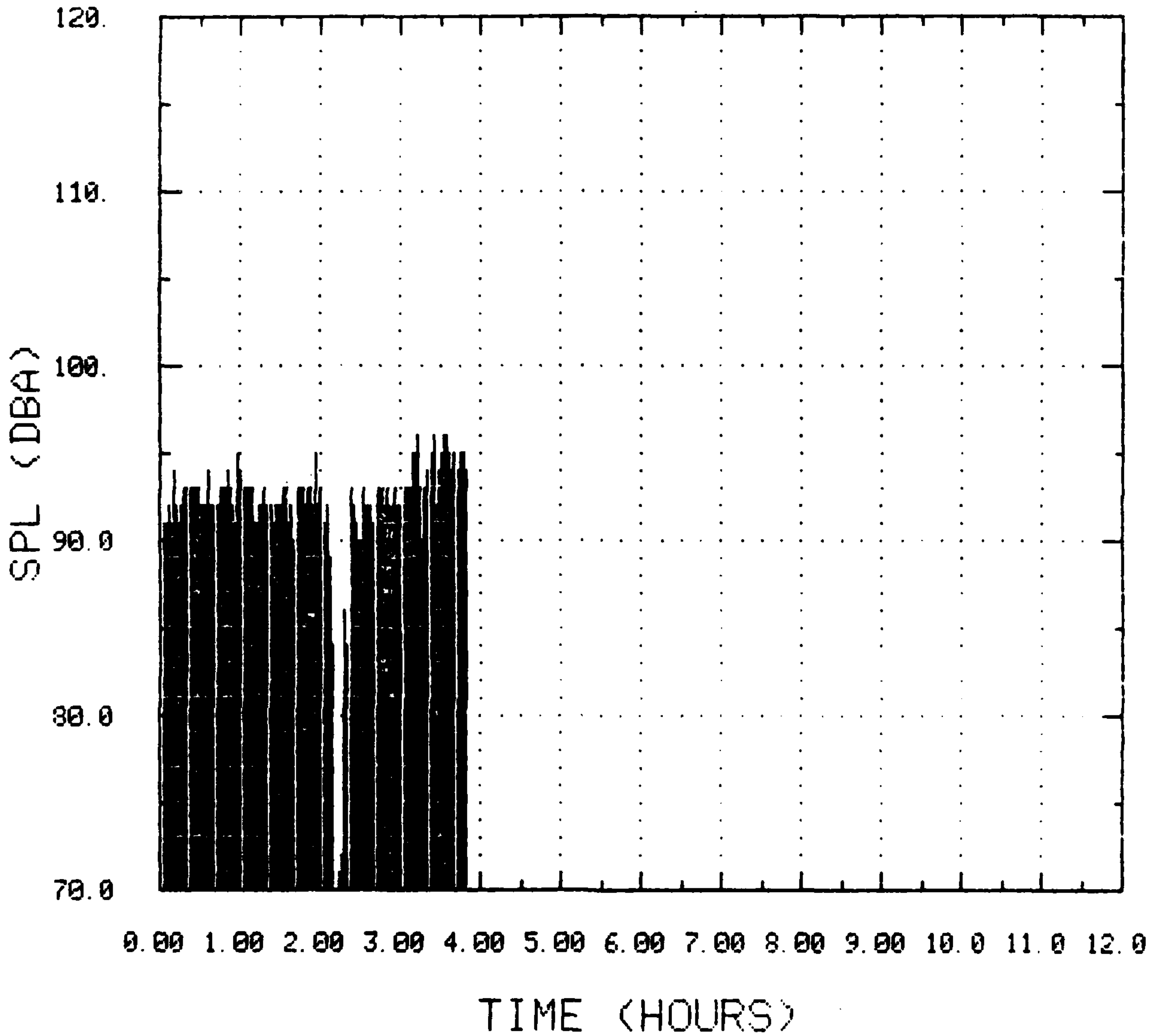

FIGURE B-25. NOISE DOSIMETRY ON SwRI PERSONNEL
(Taken during laden voyage while accompanying fireman)
Sample No. TX-9

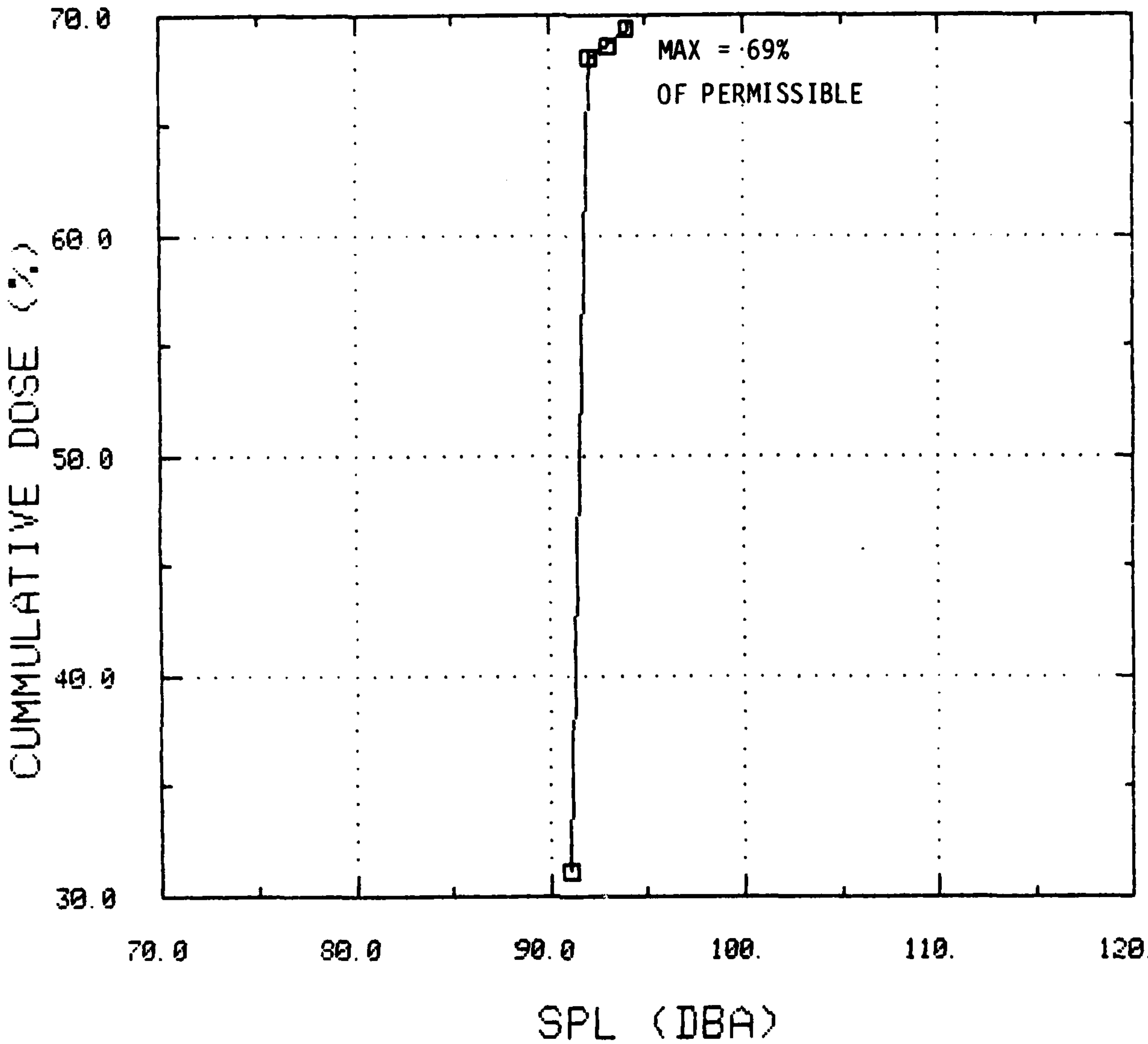

FIGURE B-24. **CUMULATIVE DOSE RECORDED**
Sample No. TX-8

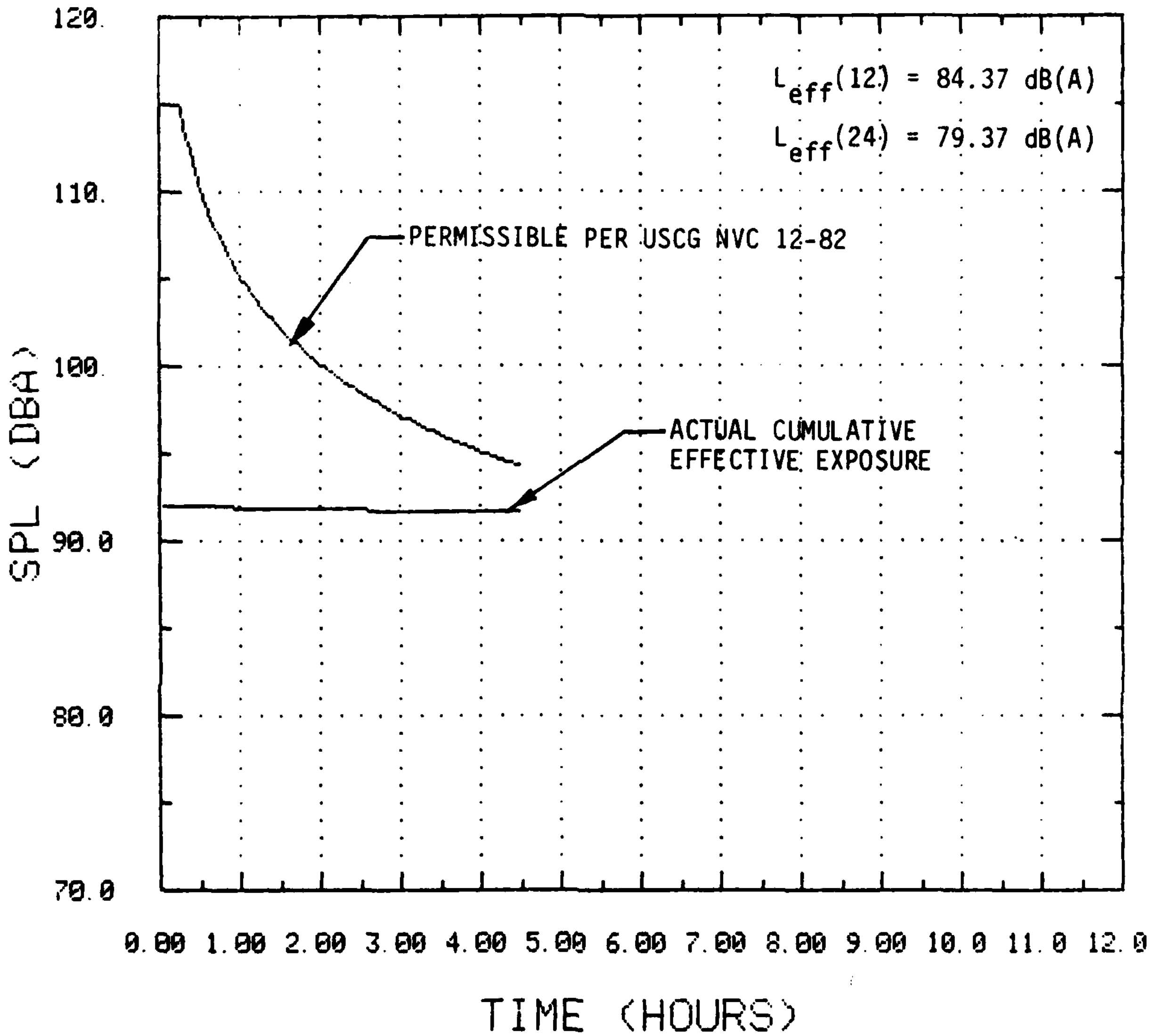

FIGURE B-23. **CUMULATIVE EFFECTIVE EXPOSURE**
Sample No. TX-8

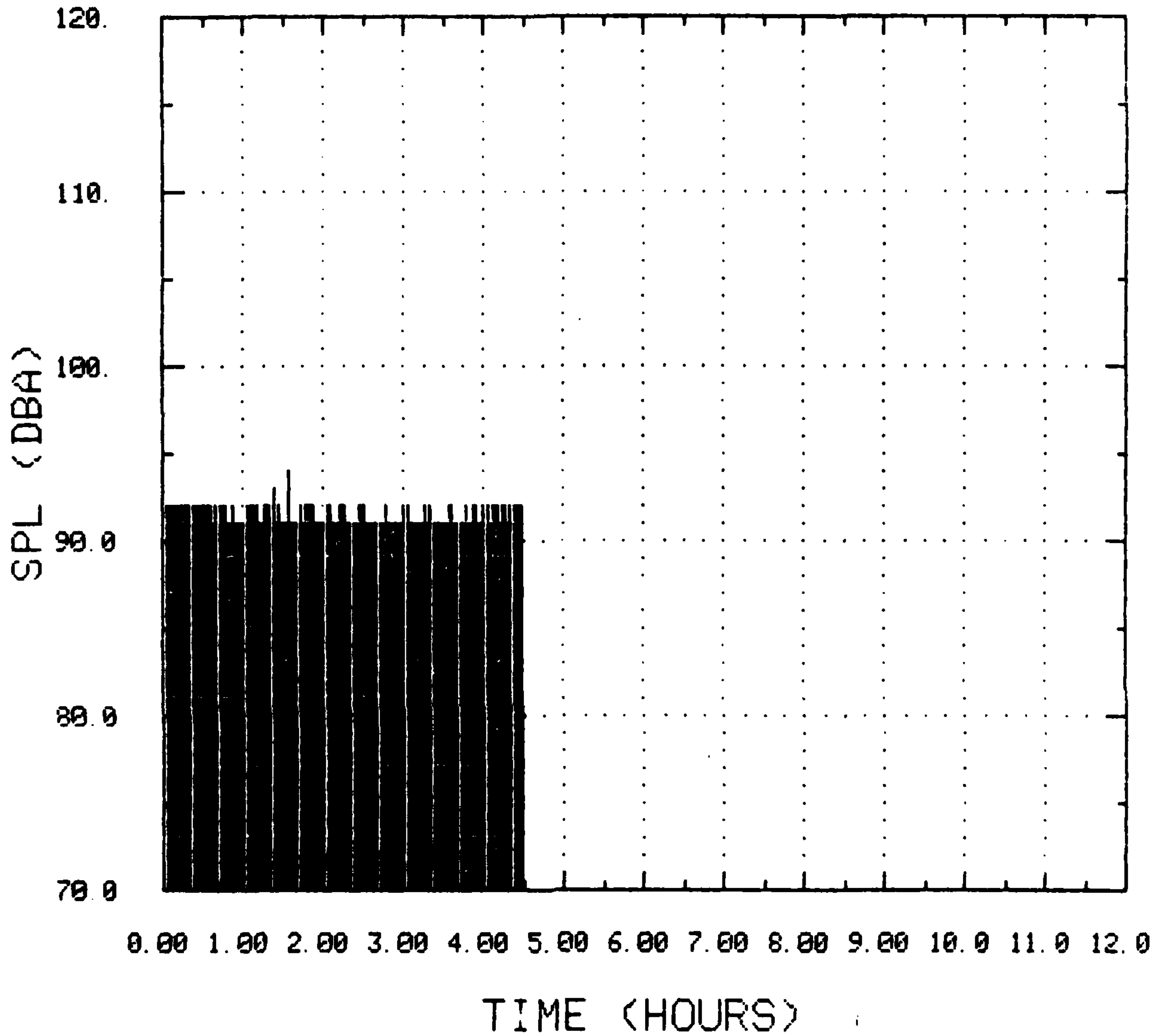

FIGURE B-22. NOISE DOSIMETRY NEAR FIREMAN'S CONTROL CONSOLE
Sample No. TX-8

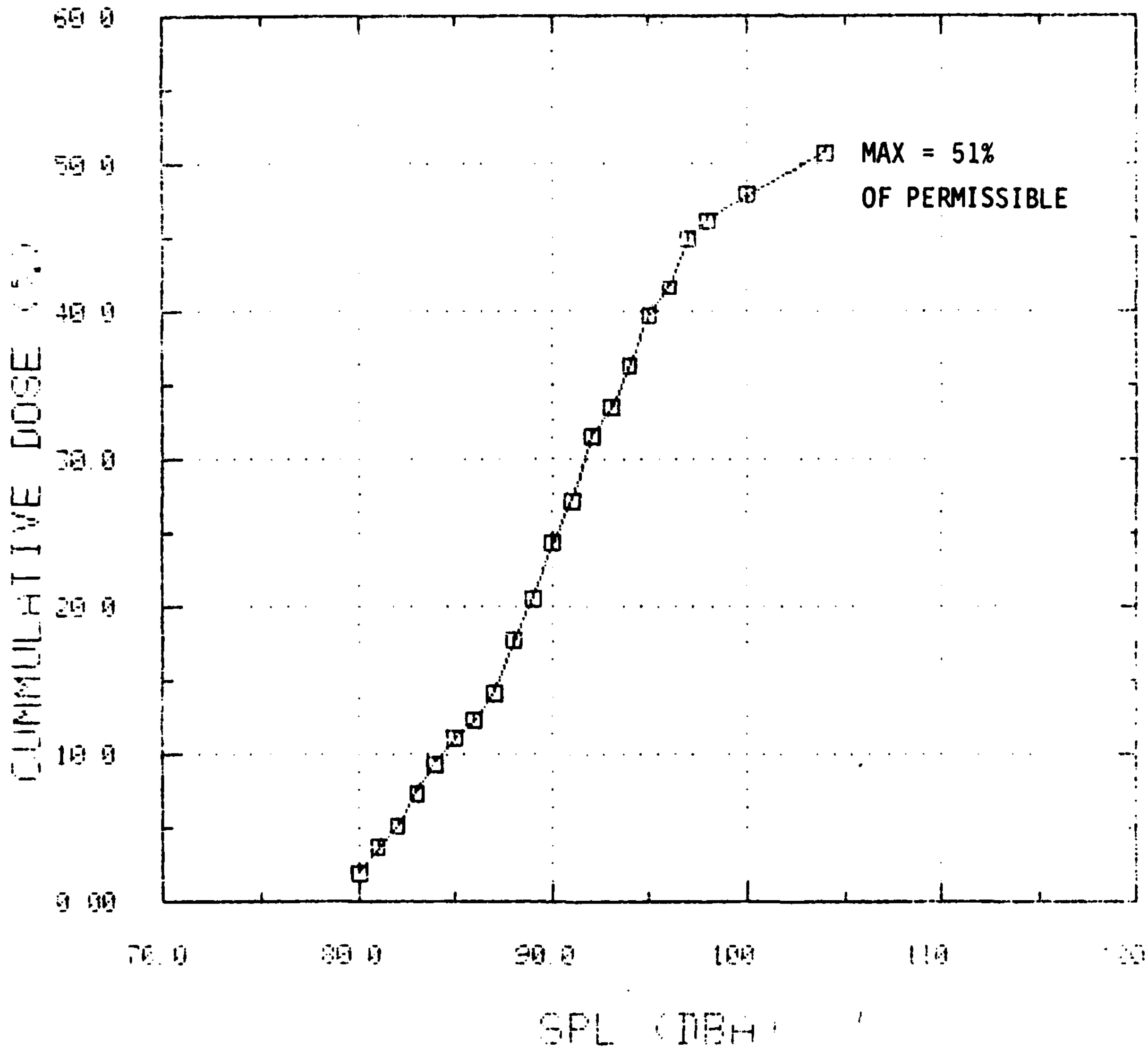

FIGURE B-21. CUMULATIVE DOSE RECORDED ON COMPANY REPRESENTATIVE Sample No. TX-7

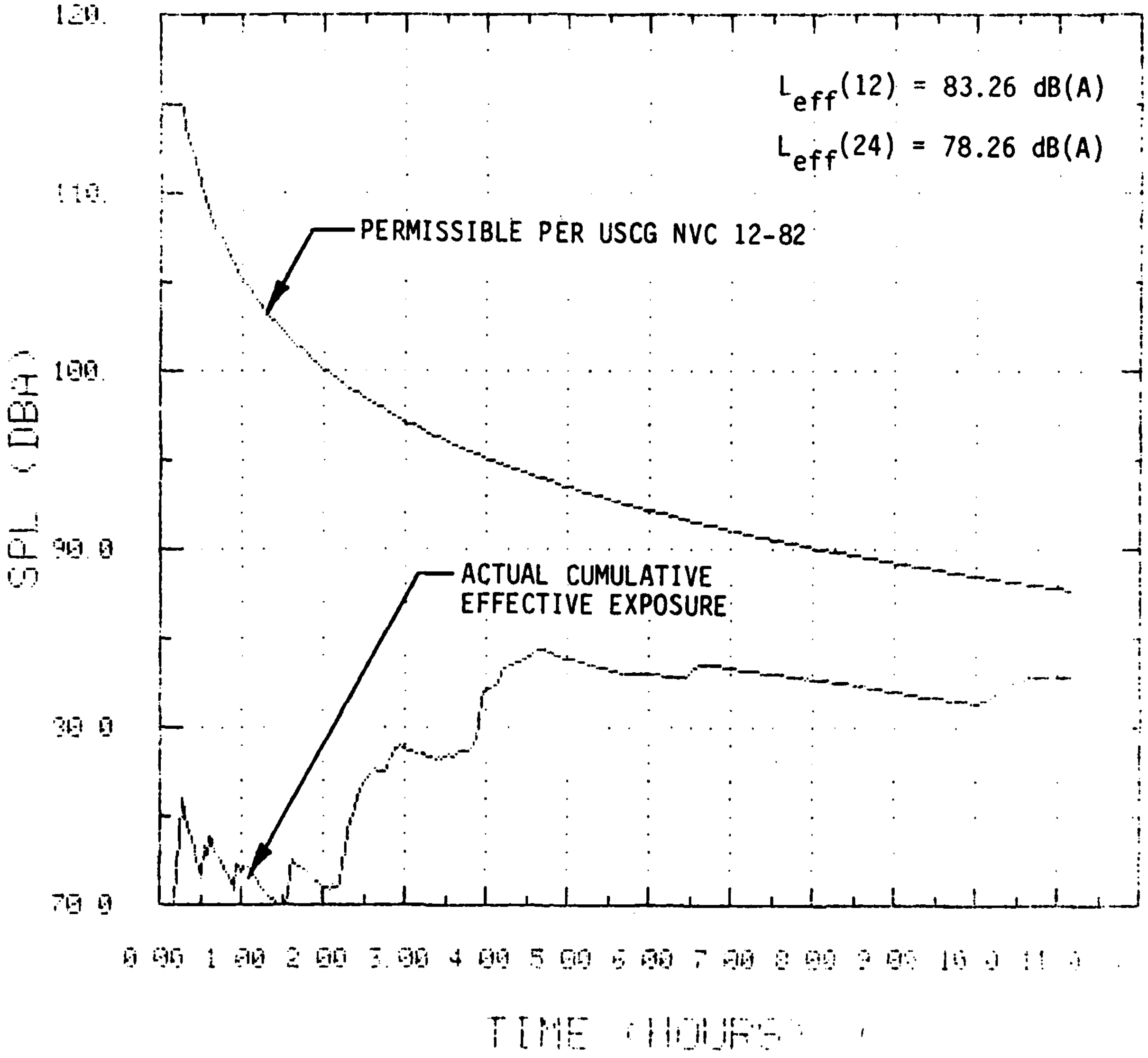

FIGURE B-20. **CUMULATIVE EFFECTIVE EXPOSURE ON COMPANY REPRESENTATIVE Sample No. TX-7**

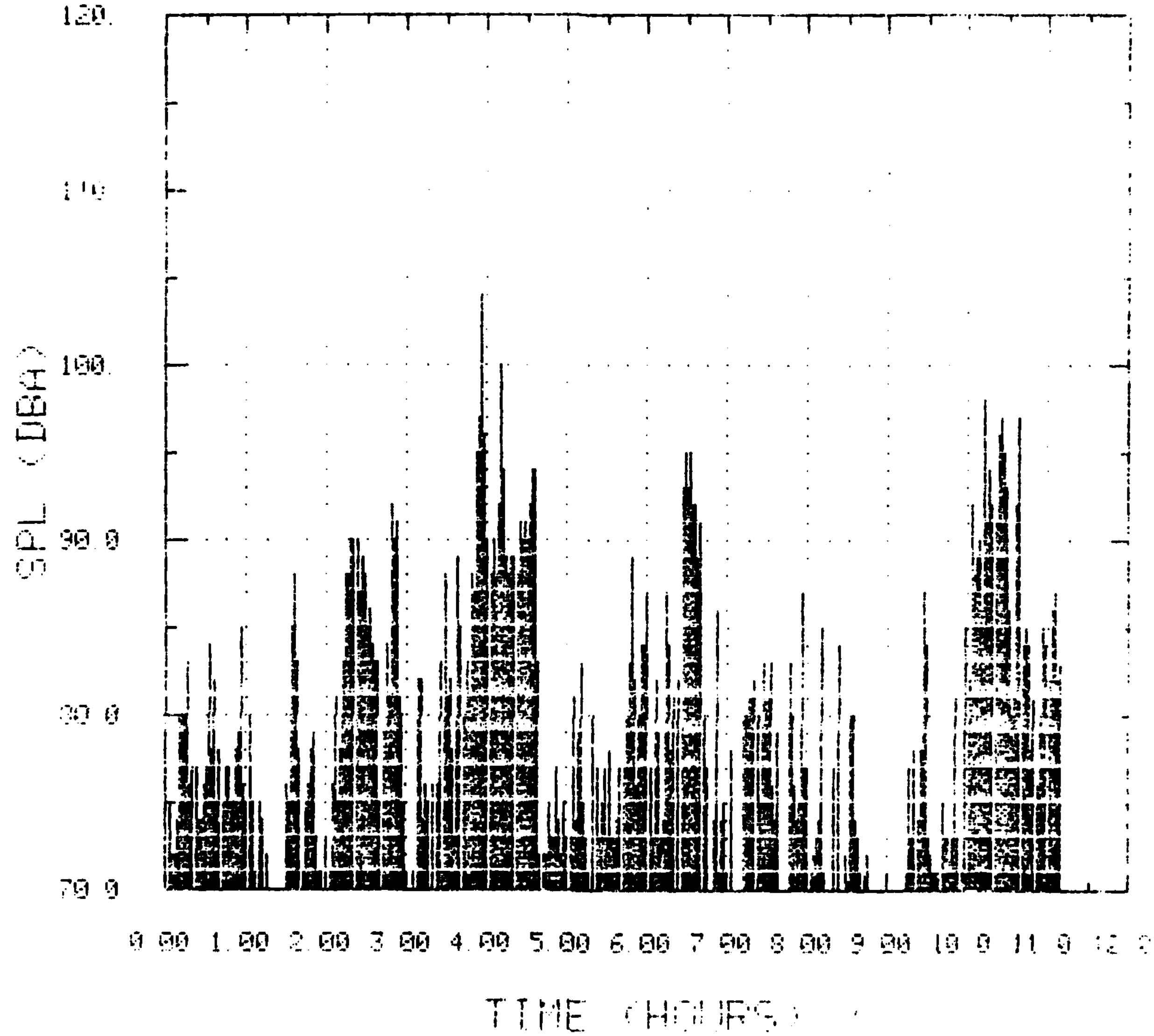

FIGURE B-19. NOISE DOSIMETRY ON COMPANY REPRESENTATIVE
(Taken During Discharge While Working on
Deck and Forward Mast)
Sample No. TX-7

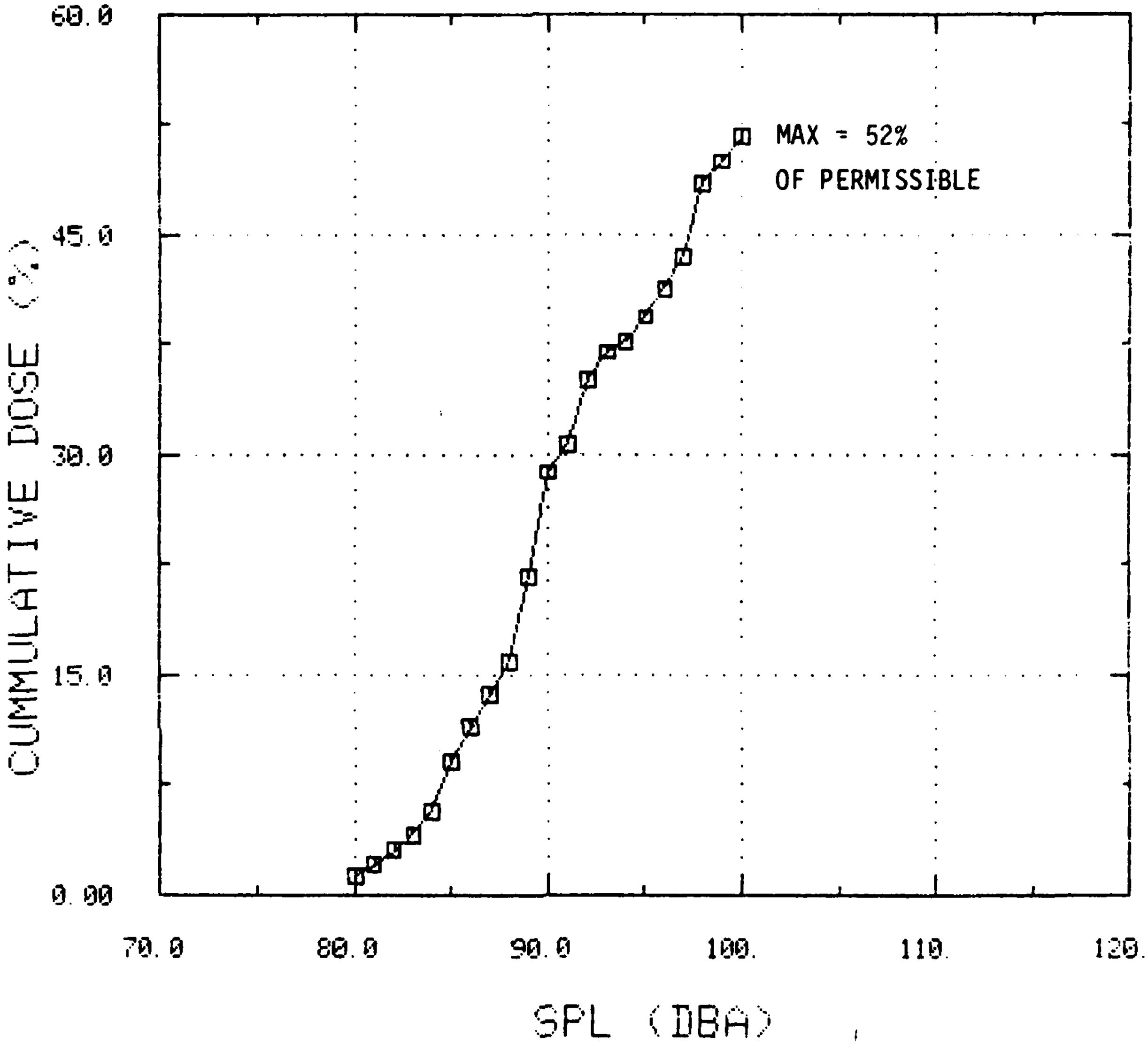

FIGURE B-18. CUMULATIVE DOSE RECORDED ON SwRI PERSONNEL
Sample No. TX-6

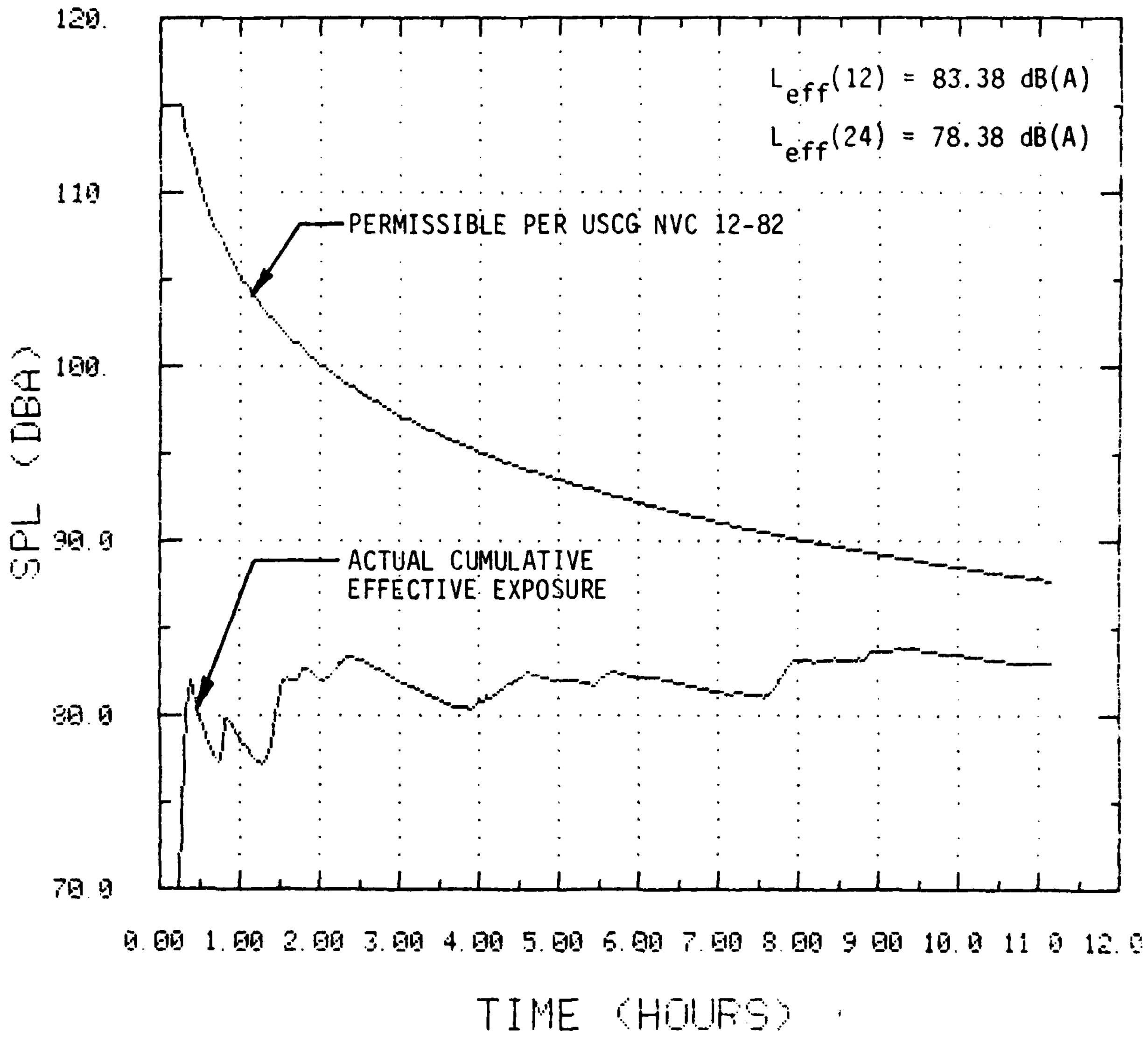

FIGURE B-17. **CUMULATIVE EFFECTIVE EXPOSURE ON SwRI PERSONNEL**
Sample No. TX-6

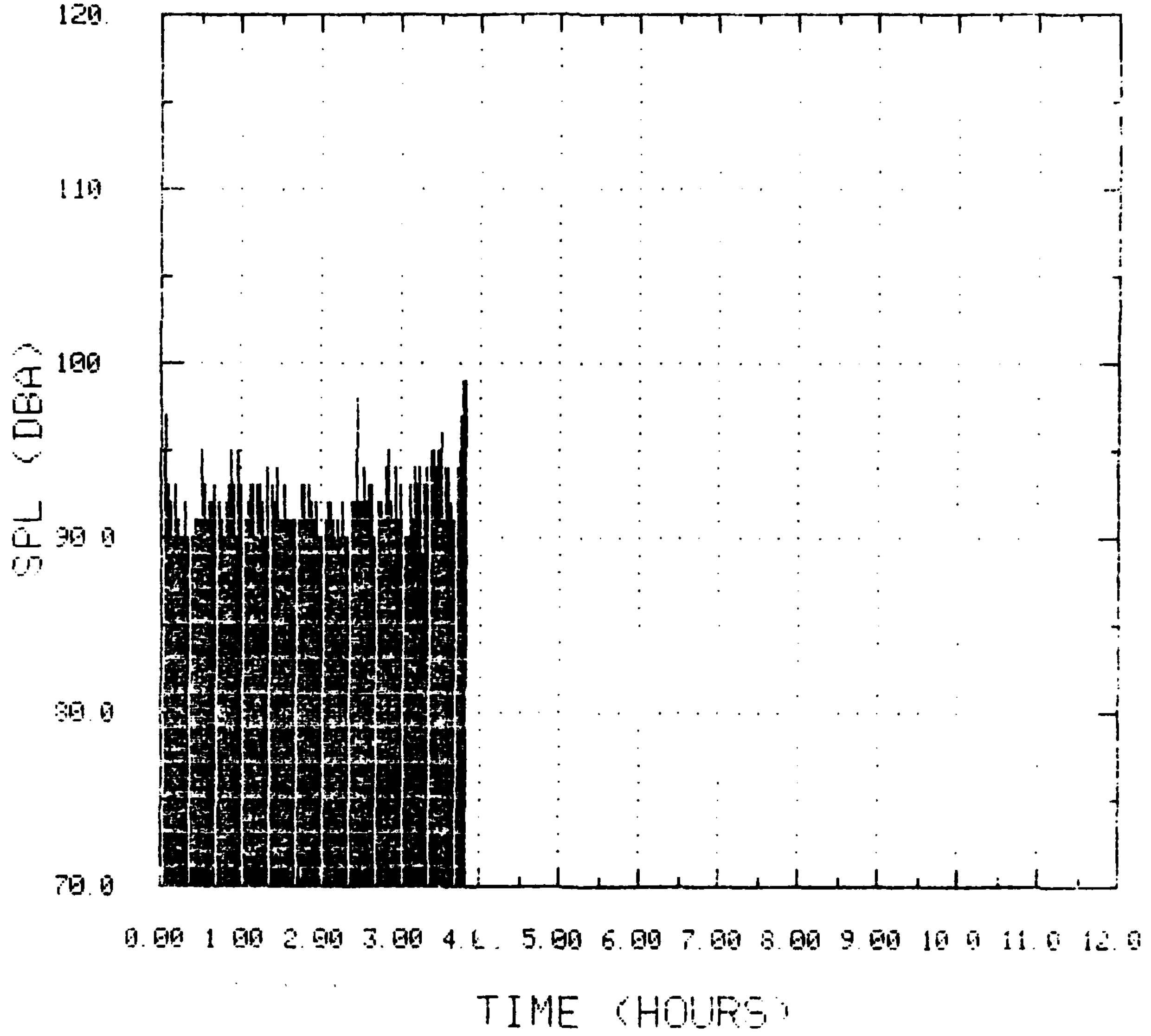

FIGURE B-31. **NOISE DOSIMETRY ON FIREMAN**
(Taken during laden voyage)
Sample No. TX-11A

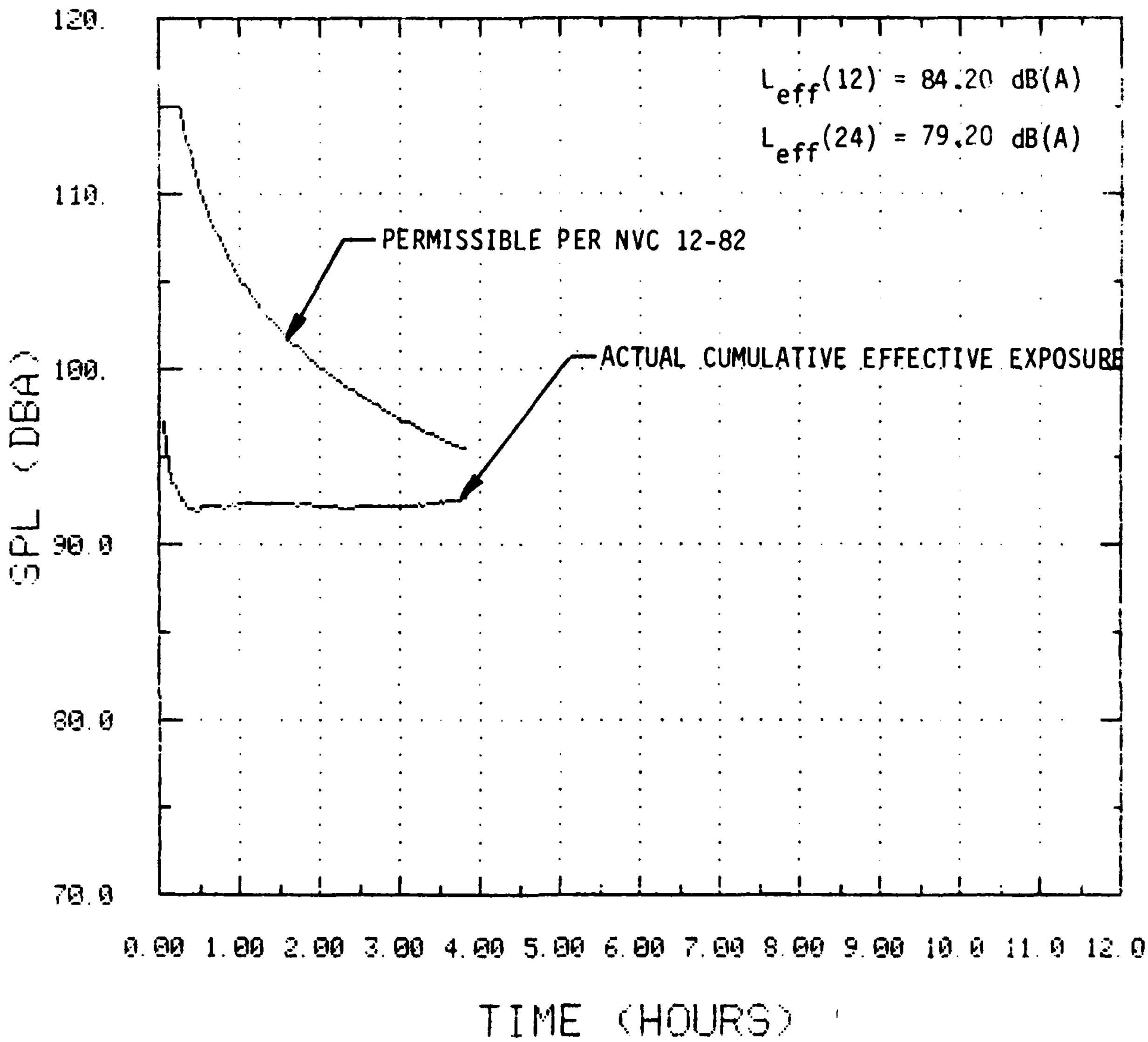

FIGURE B-32. **CUMULATIVE EFFECTIVE EXPOSURE ON FIREMAN Sample No. TX-11A**

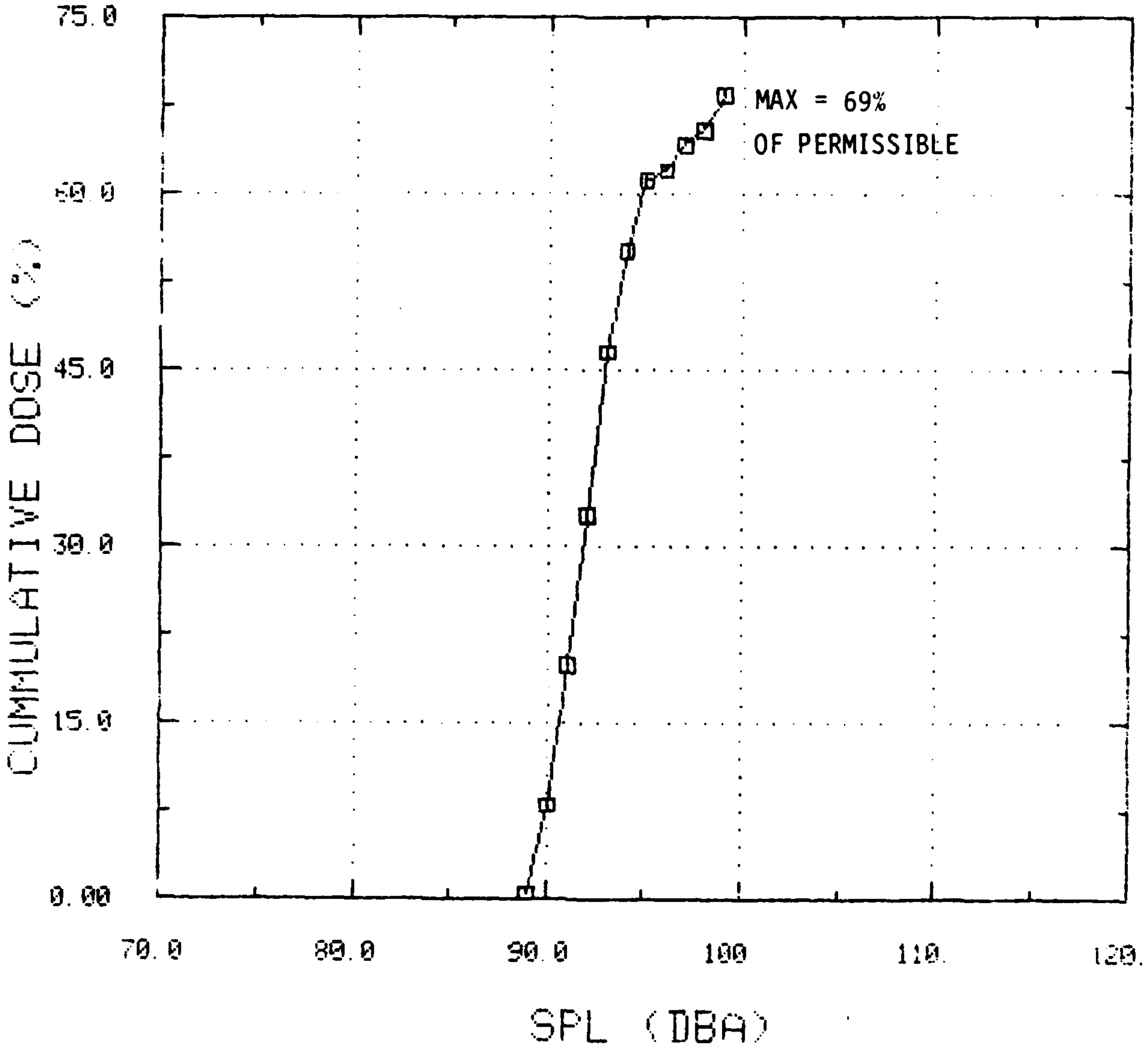

FIGURE B-33. **CUMULATIVE DOSE RECORDED ON FIREMAN**
Sample No. TX-11A

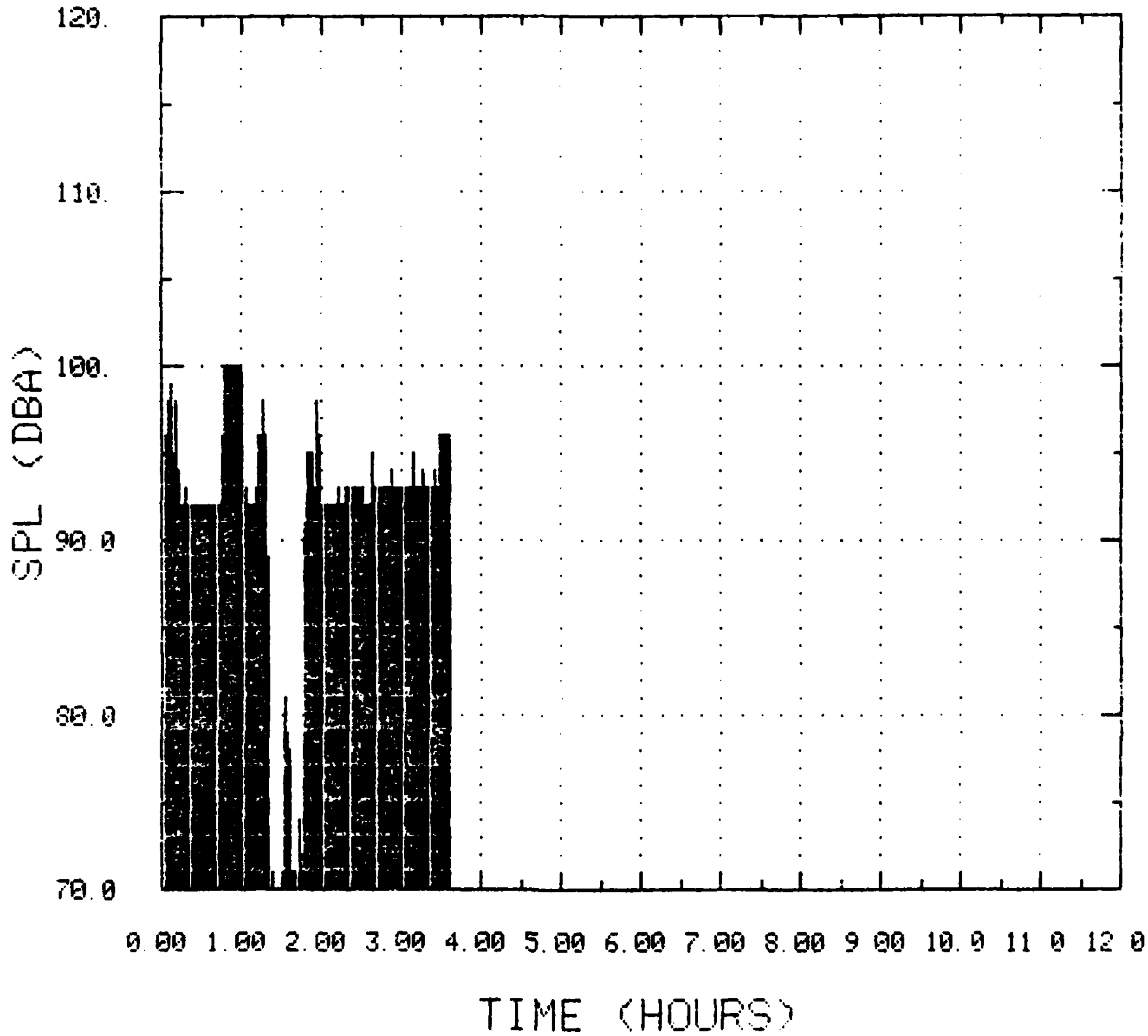

FIGURE B-34. NOISE DOSIMETRY ON FIREMAN
(Taken during laden voyage)
Sample No. TX-11B

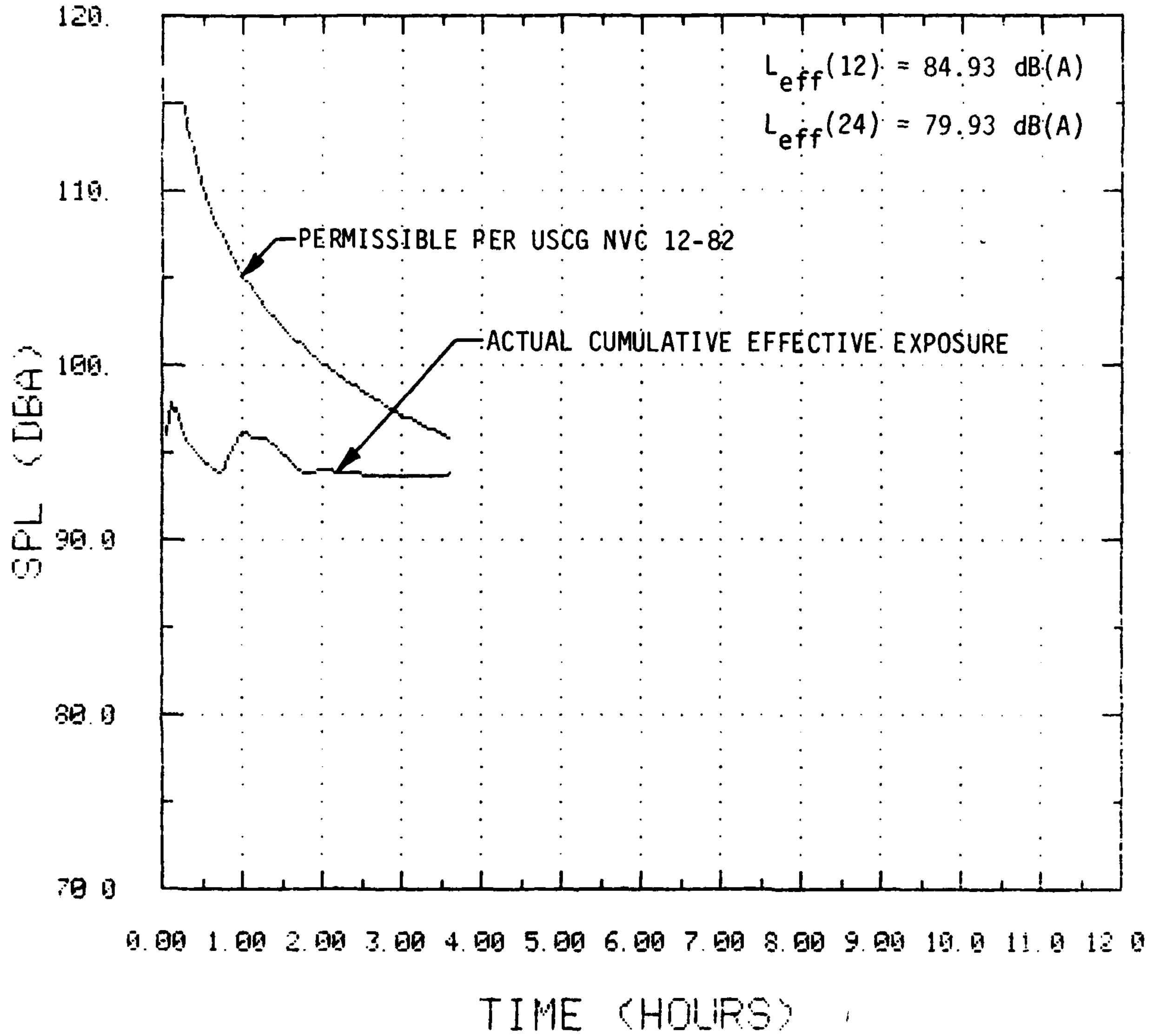

FIGURE B-35. CUMULATIVE EFFECTIVE EXPOSURE ON FIREMAN
Sample No. TX-11B

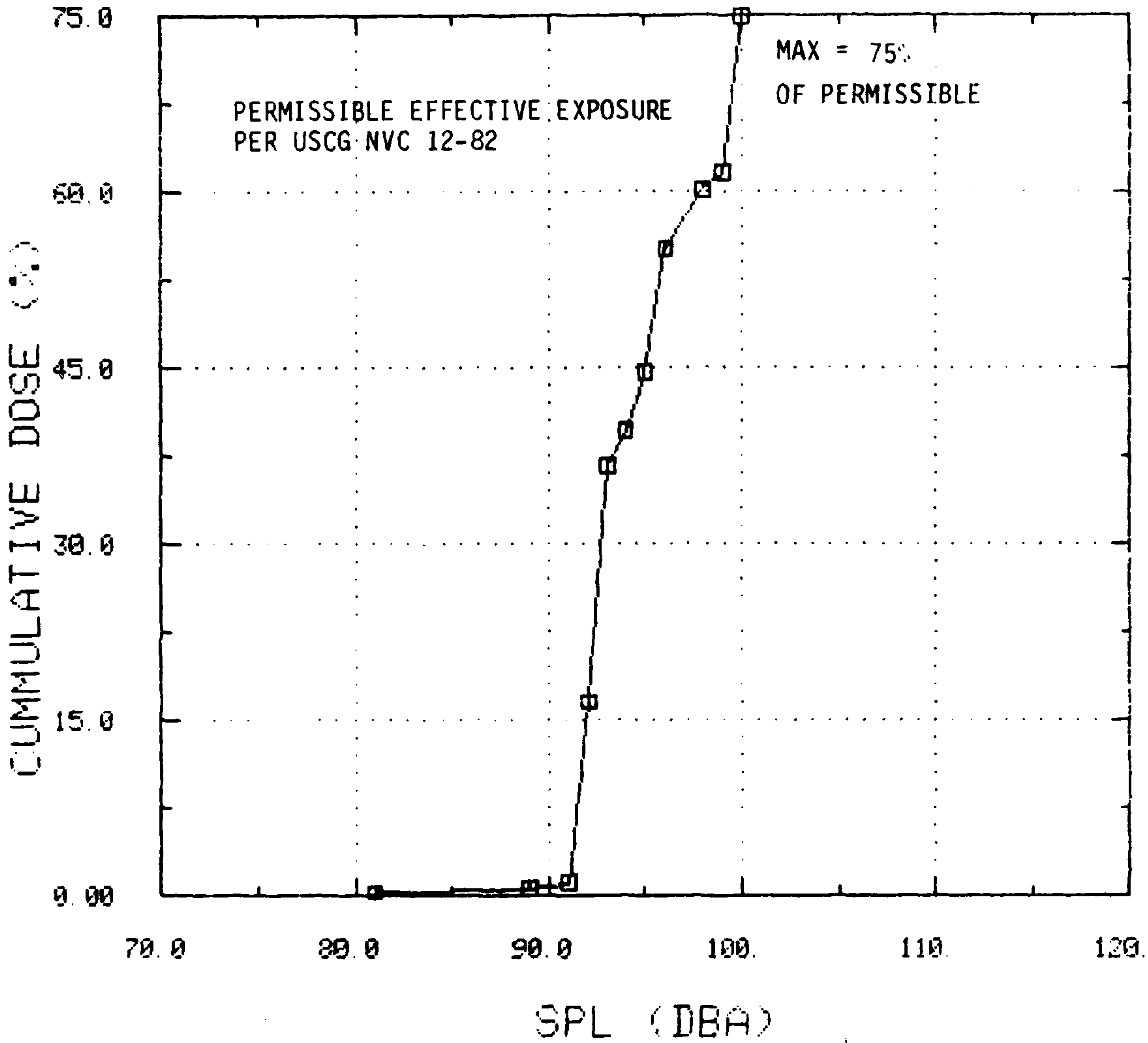

FIGURE B-36. **CUMULATIVE DOSE RECORDED ON FIREMAN**
Sample No. TX-11B

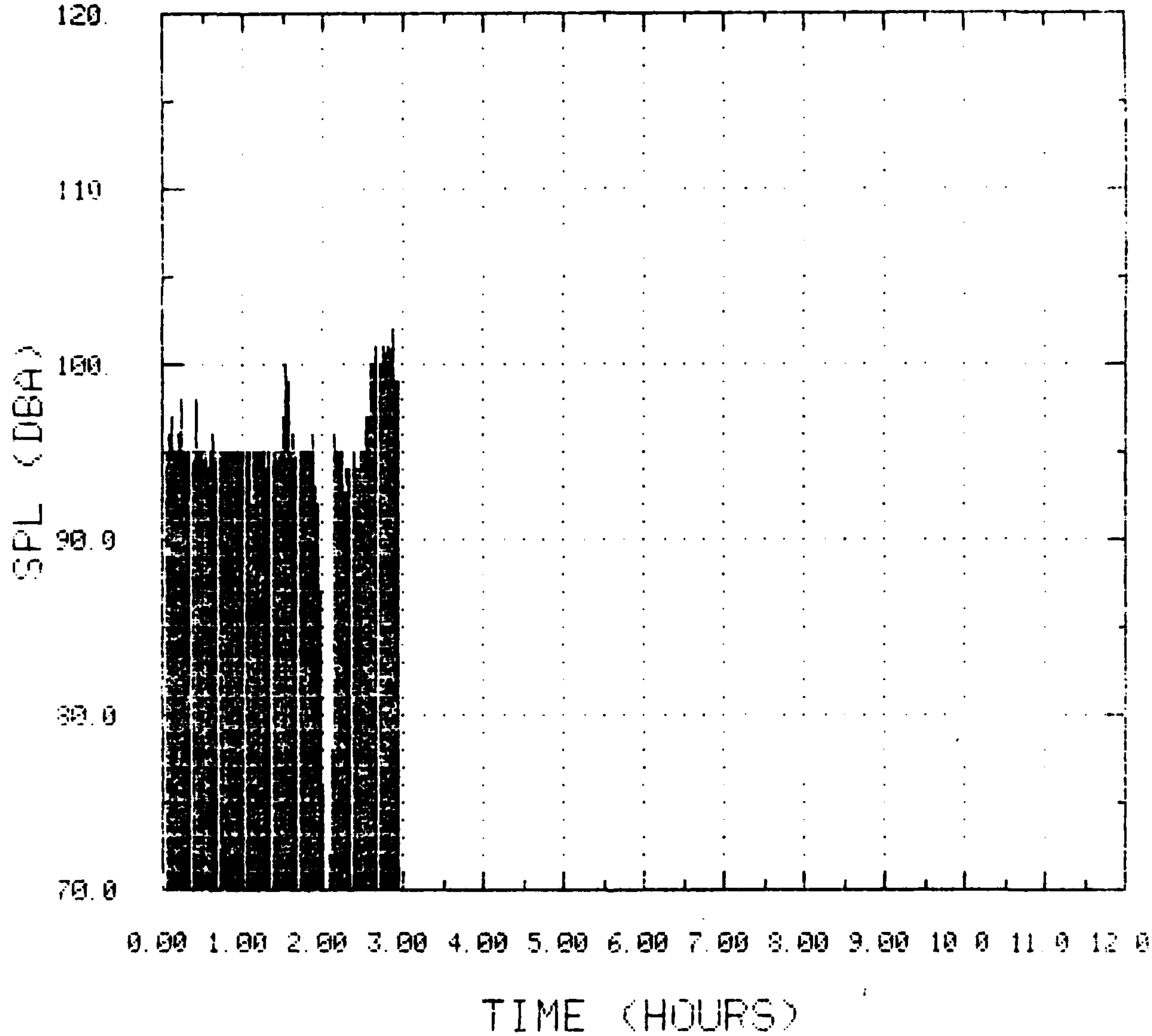

FIGURE B-37. NOISE DOSIMETRY ON OILER
(Taken during laden voyage)
Sample No. TX-12A

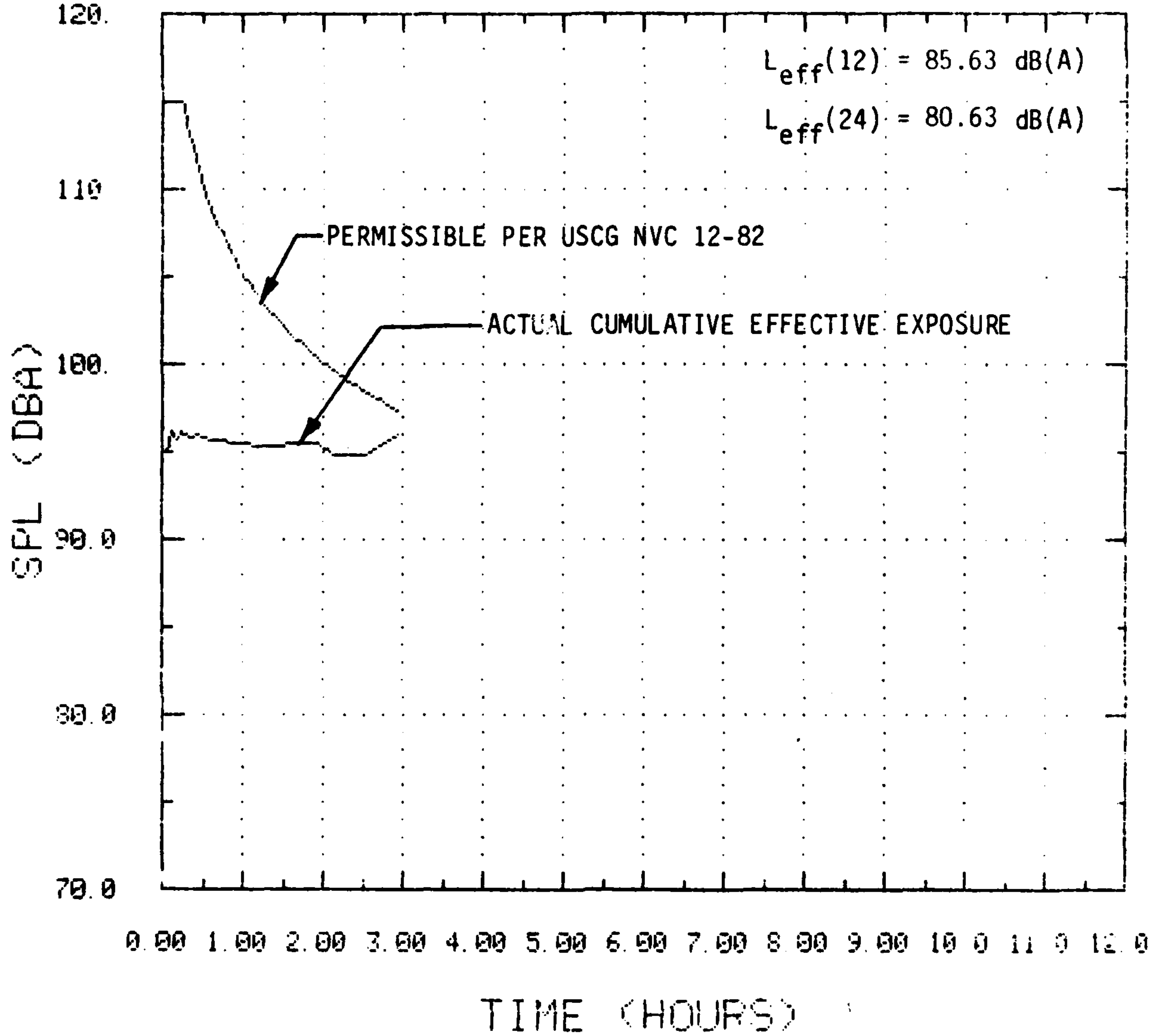

FIGURE B-38. **CUMULATIVE EFFECTIVE EXPOSURE ON OILER**
Sample No. TX-12A

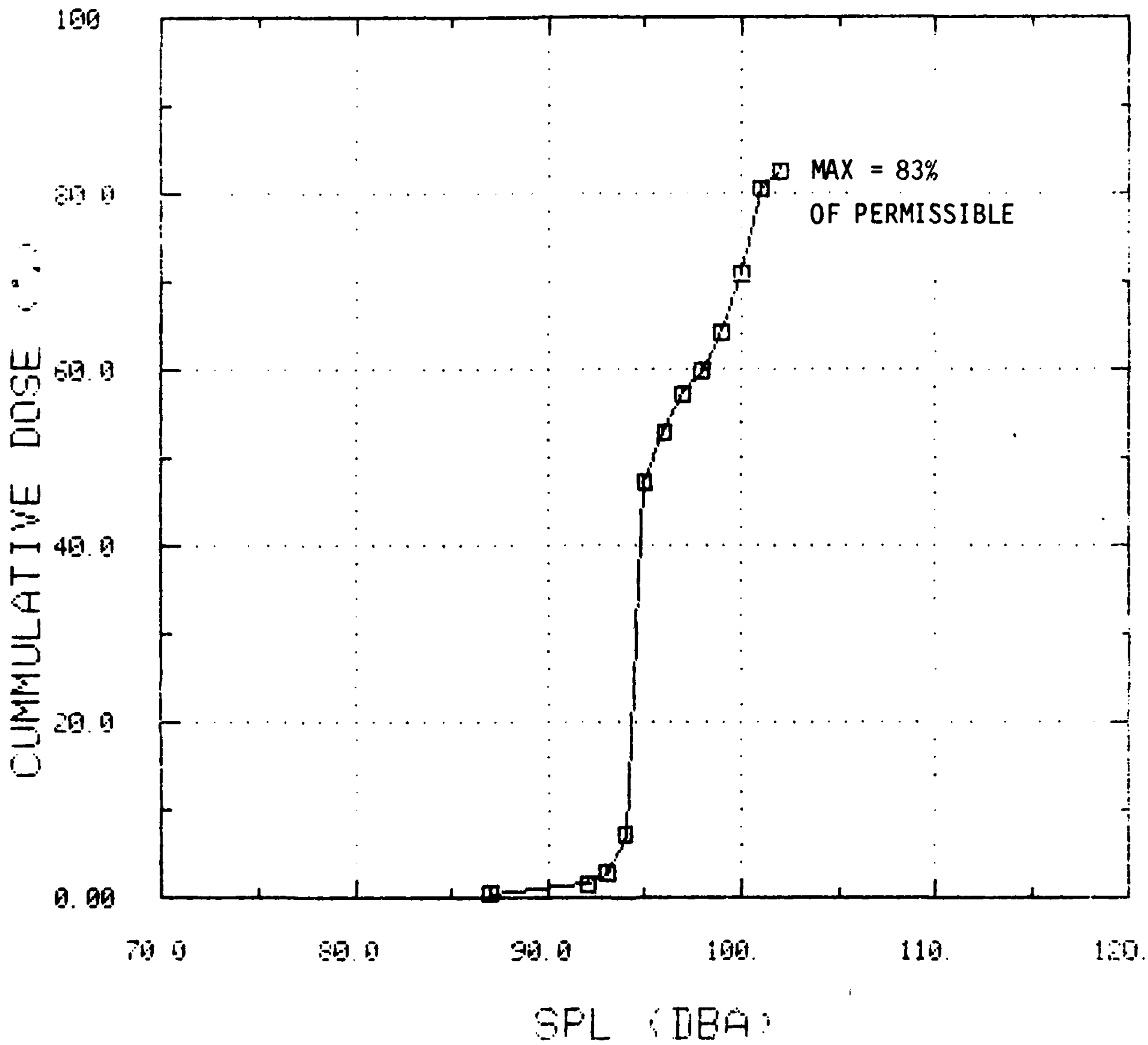

FIGURE B-39. CUMULATIVE DOSE RECORDED ON OILER
Sample No. TX-12A

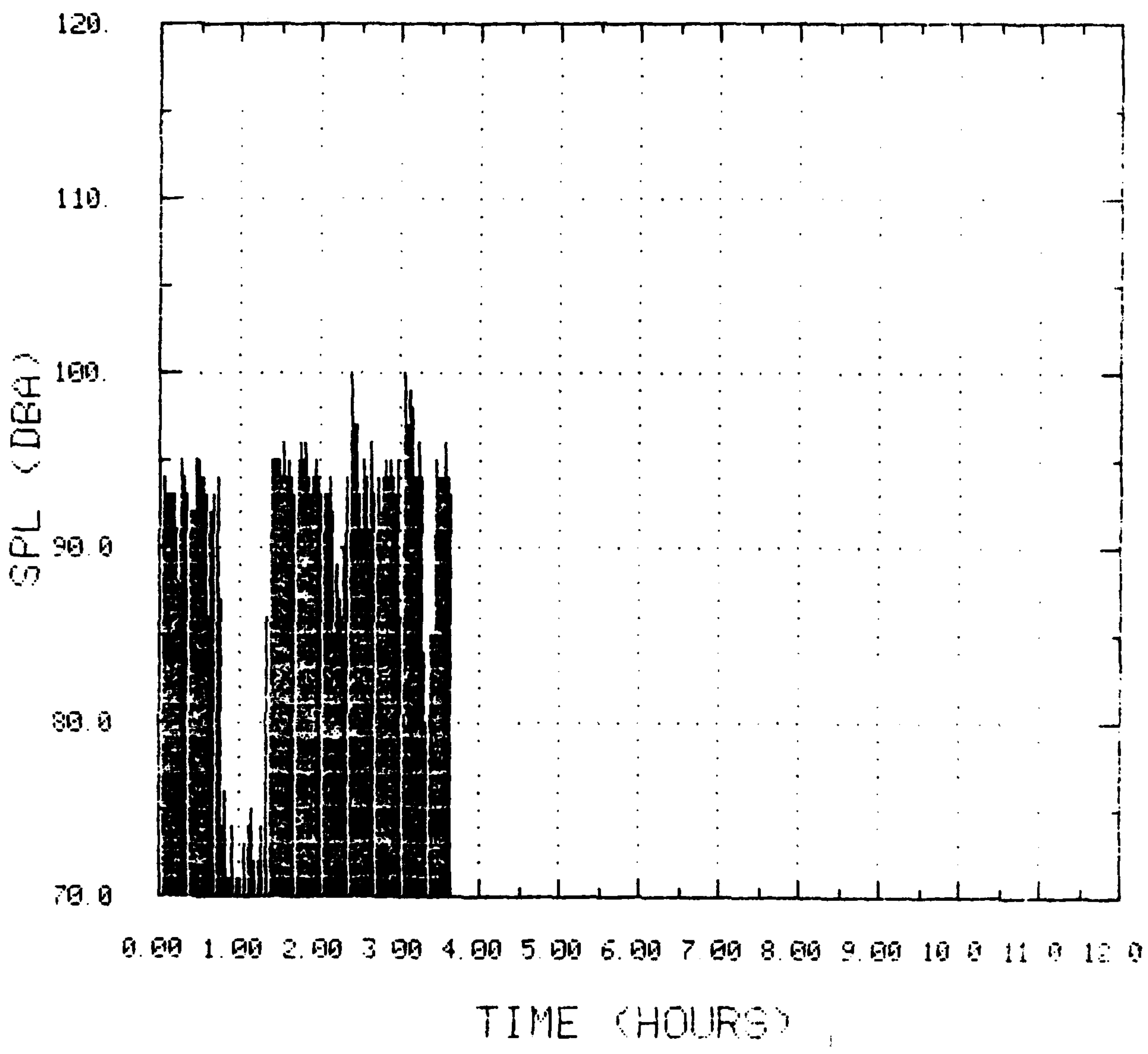

FIGURE B-40. NOISE DOSIMETRY ON OILER
(Taken during laden voyage)
Sample No. TX-12B

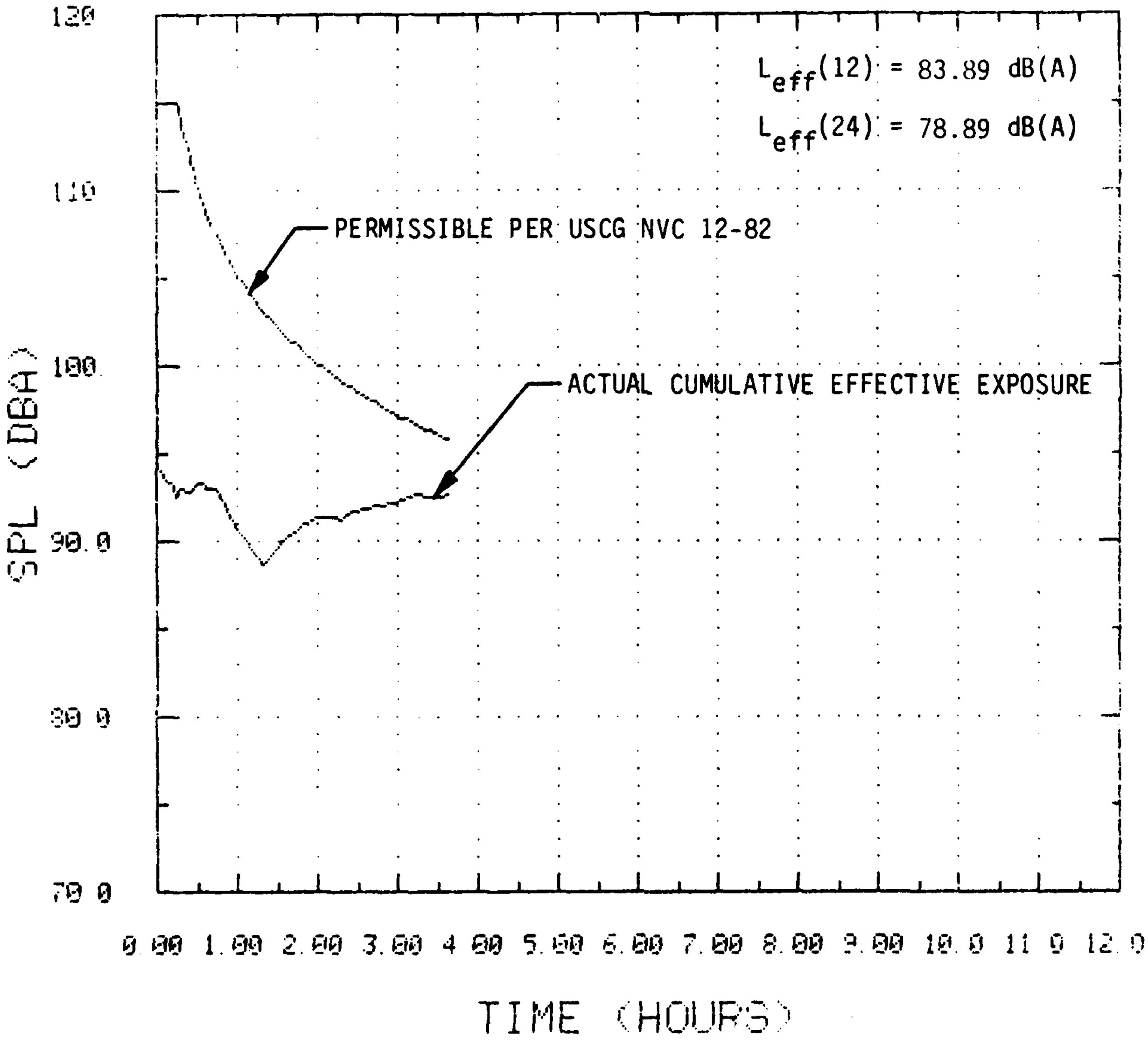

FIGURE B-41. **CUMULATIVE EFFECTIVE EXPOSURE ON OILER Sample No. TX-12B**

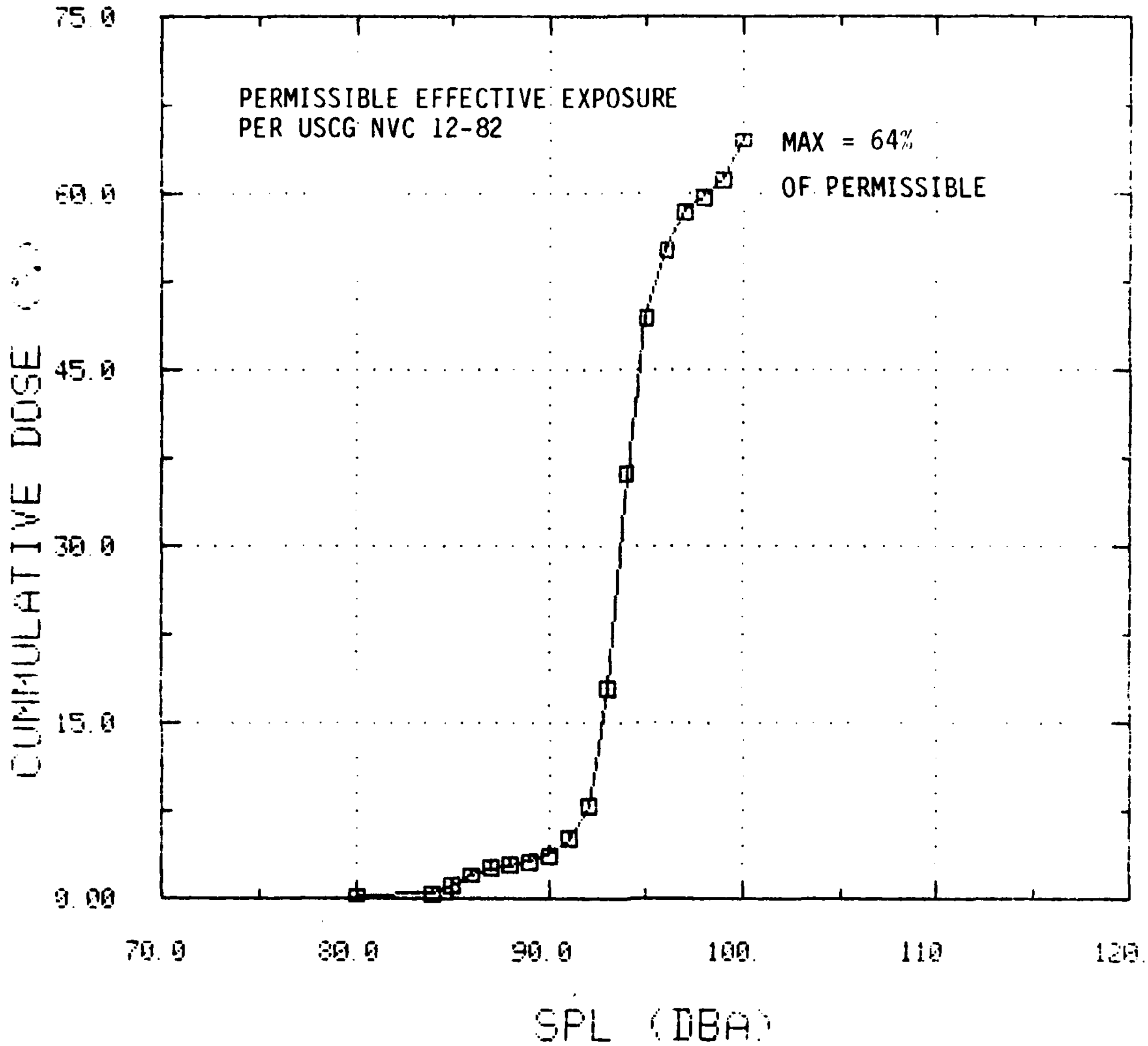

FIGURE B-42. **CUMULATIVE DOSE RECORDED ON OILER**
Sample No. TX-12B

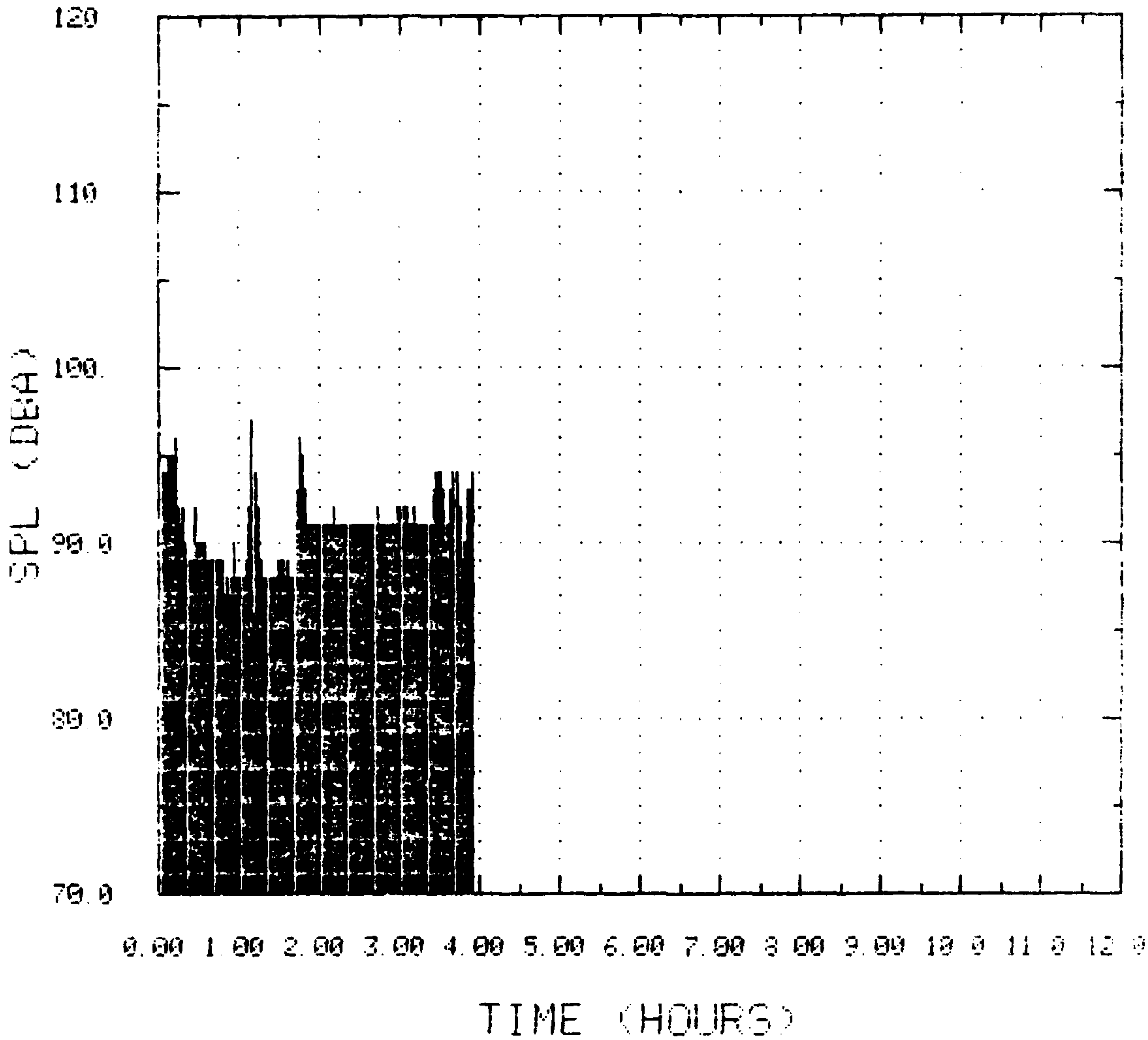

FIGURE B-43. **NOISE DOSIMETRY ON ASSISTANT ENGINEER**
(Taken during laden voyage)
Sample No. TX-13A

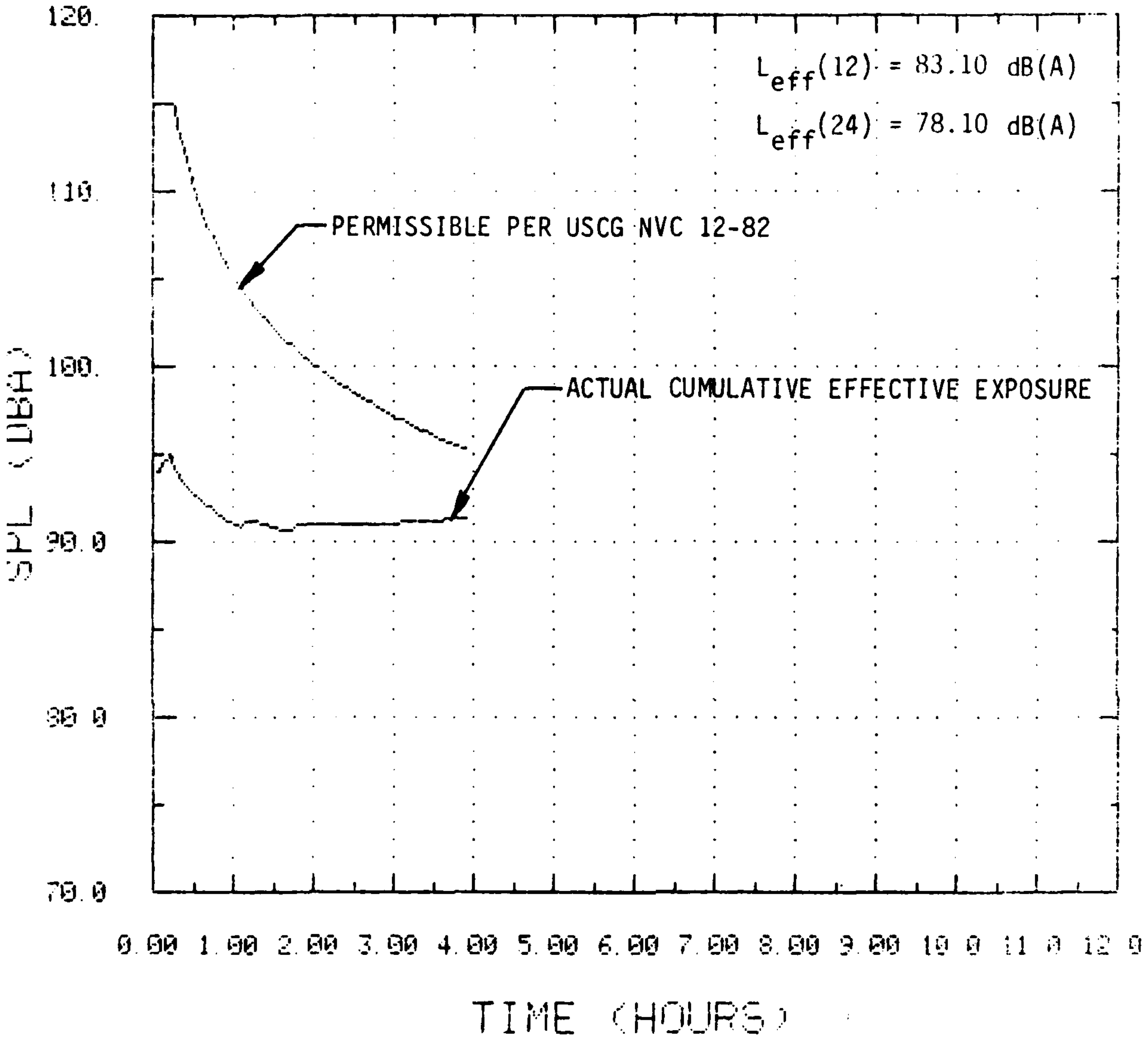

FIGURE B-44. **CUMULATIVE EFFECTIVE EXPOSURE ON ASSISTANT ENGINEER Sample No. TX-13A**

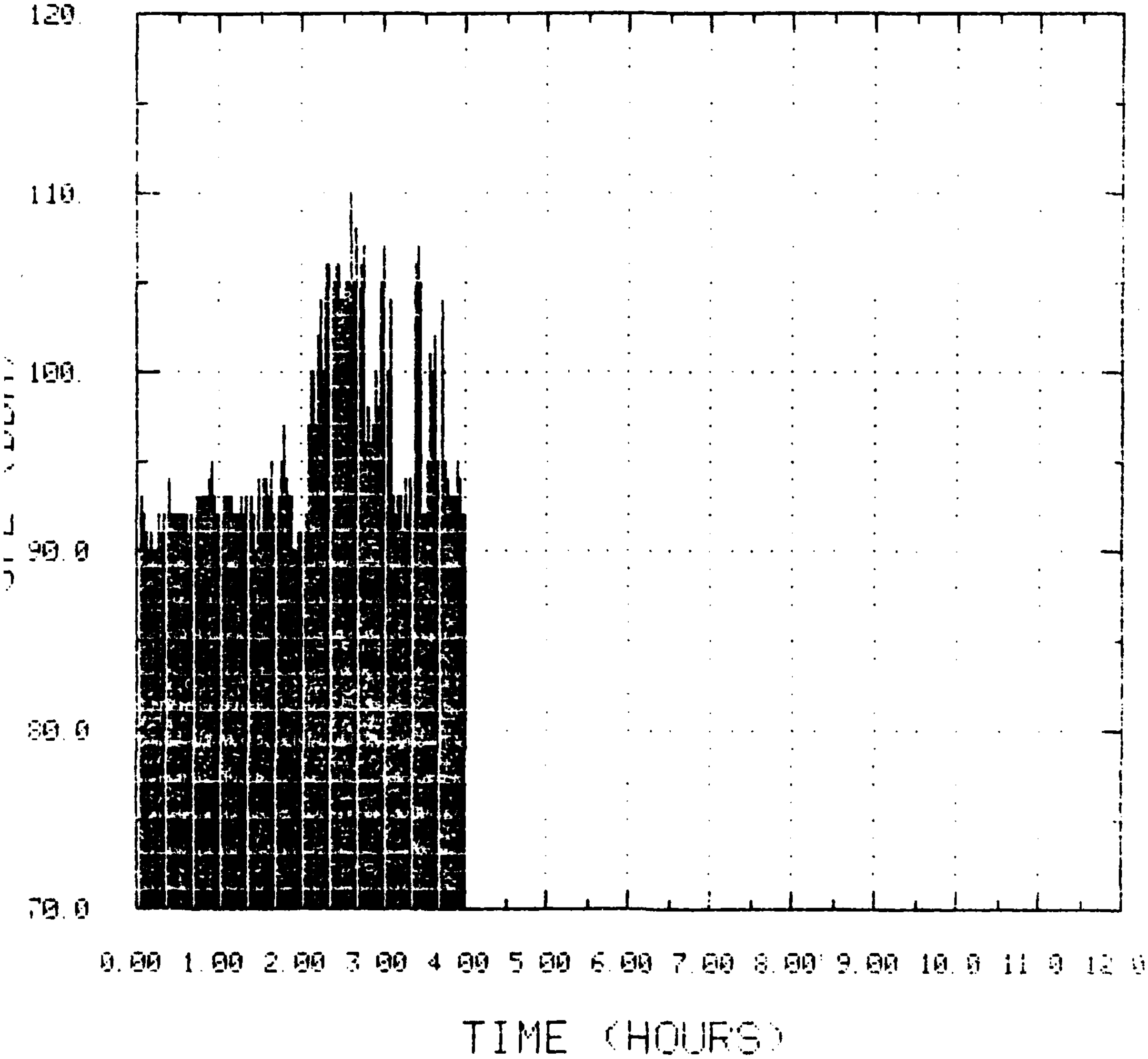

FIGURE B-58. **NOISE DOSIMETRY ON ASSISTANT ENGINEER (Taken during laden voyage) Sample No. TX-15B**

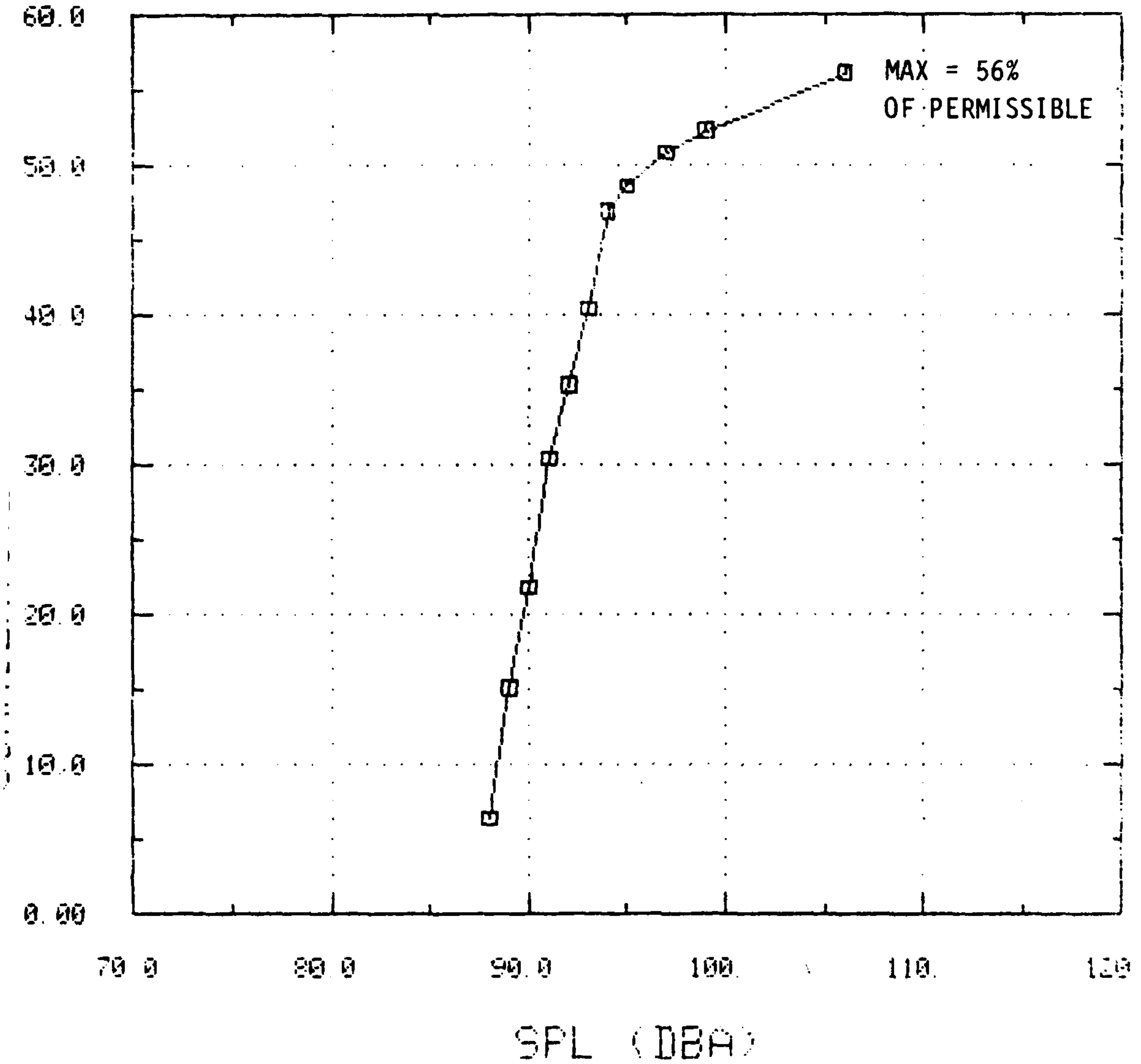

FIGURE B-57. **CUMULATIVE DOSE RECORDED ON FIREMAN**
Sample No. TX-15A

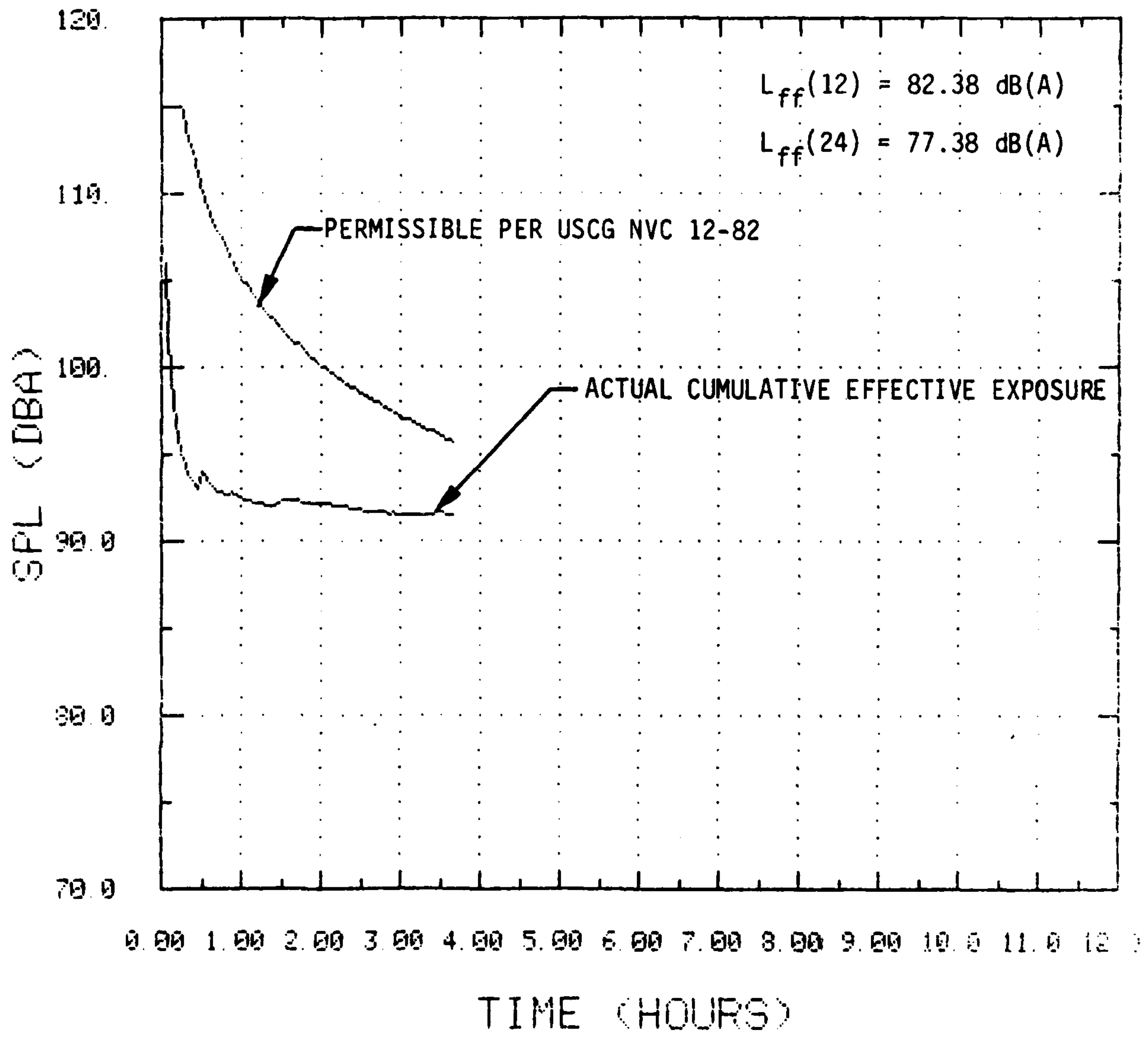

FIGURE B-56. **CUMULATIVE EFFECTIVE EXPOSURE ON FIREMAN**
Sample No. TX-15A

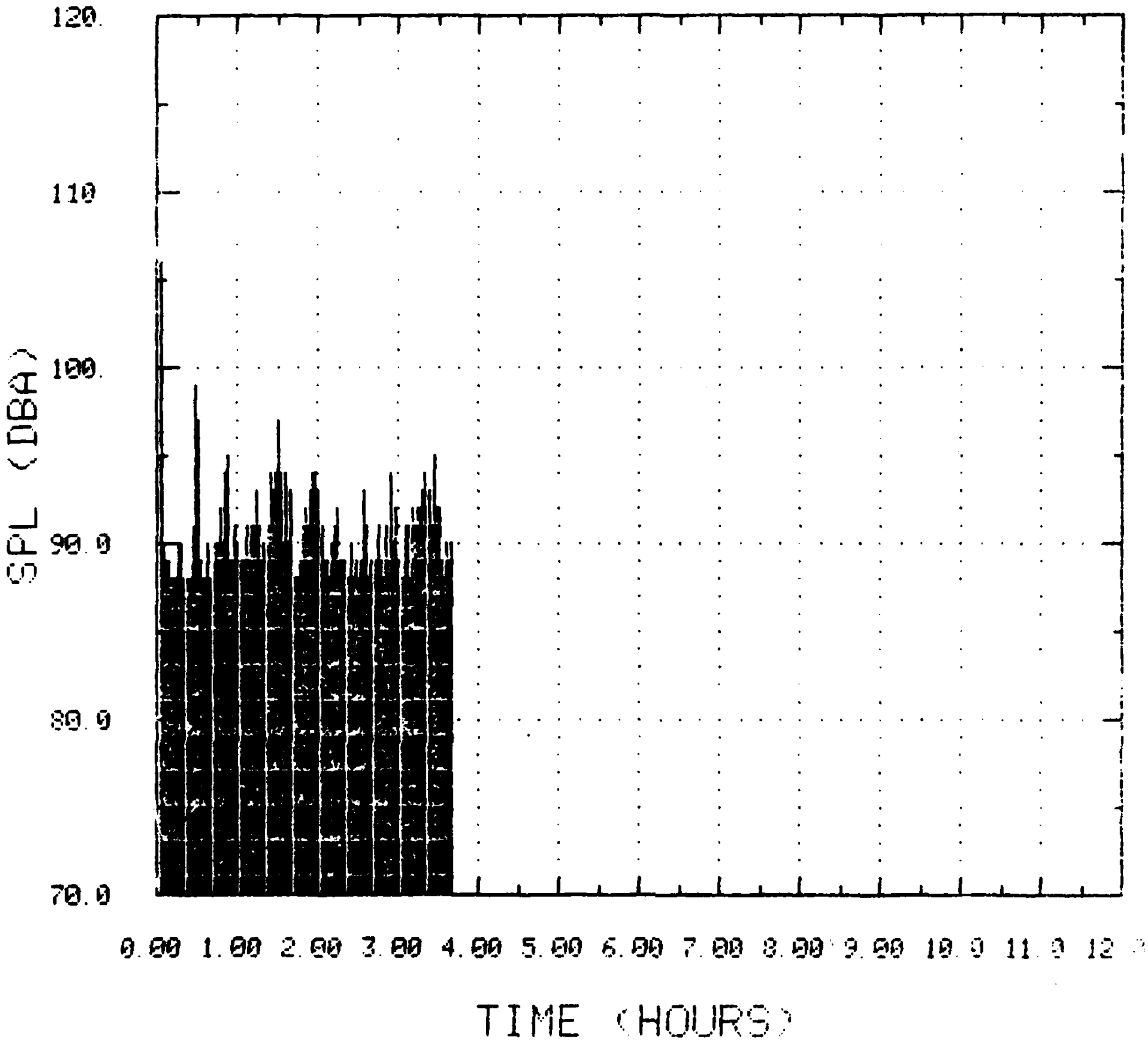

FIGURE B-55. **NOISE DOSIMETRY ON FIREMAN**
(Taken during laden voyage)
Sample No. TX-15A

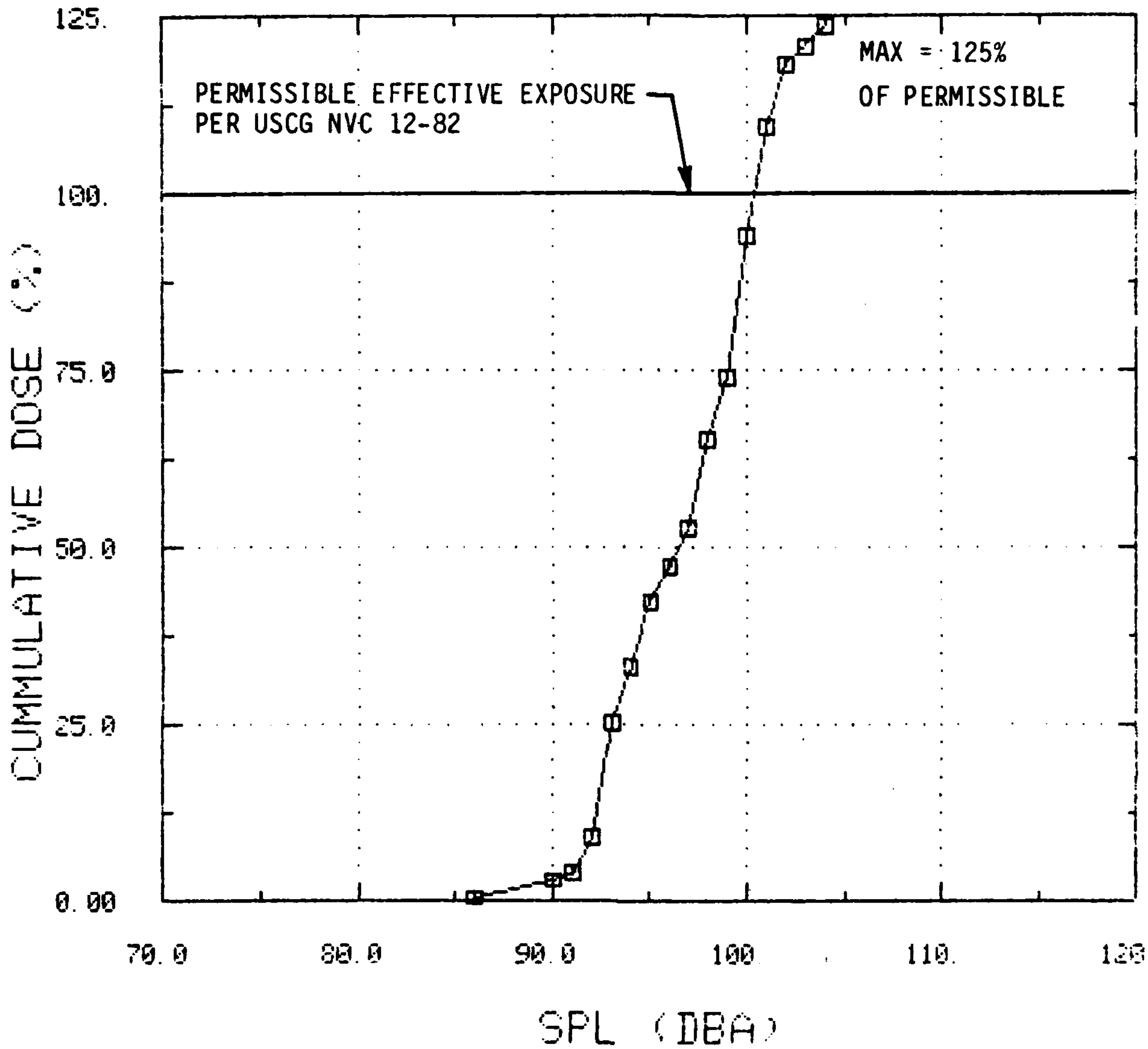

FIGURE B-54. **CUMULATIVE DOSE RECORDED ON OILER**
Sample No. TX-14B

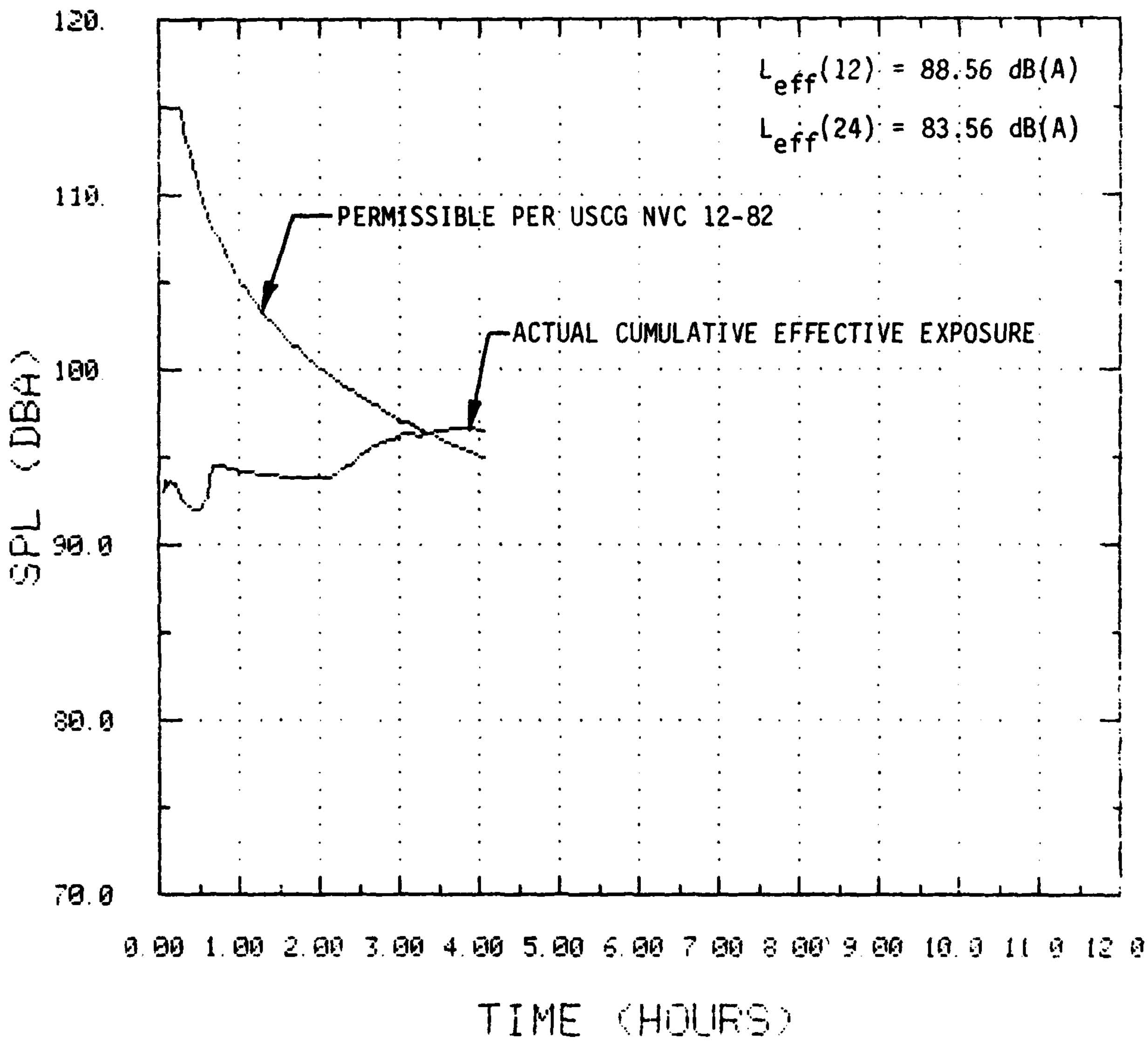

FIGURE B-53. **CUMULATIVE EFFECTIVE EXPOSURE ON OILER**
Sample No. TX-14B

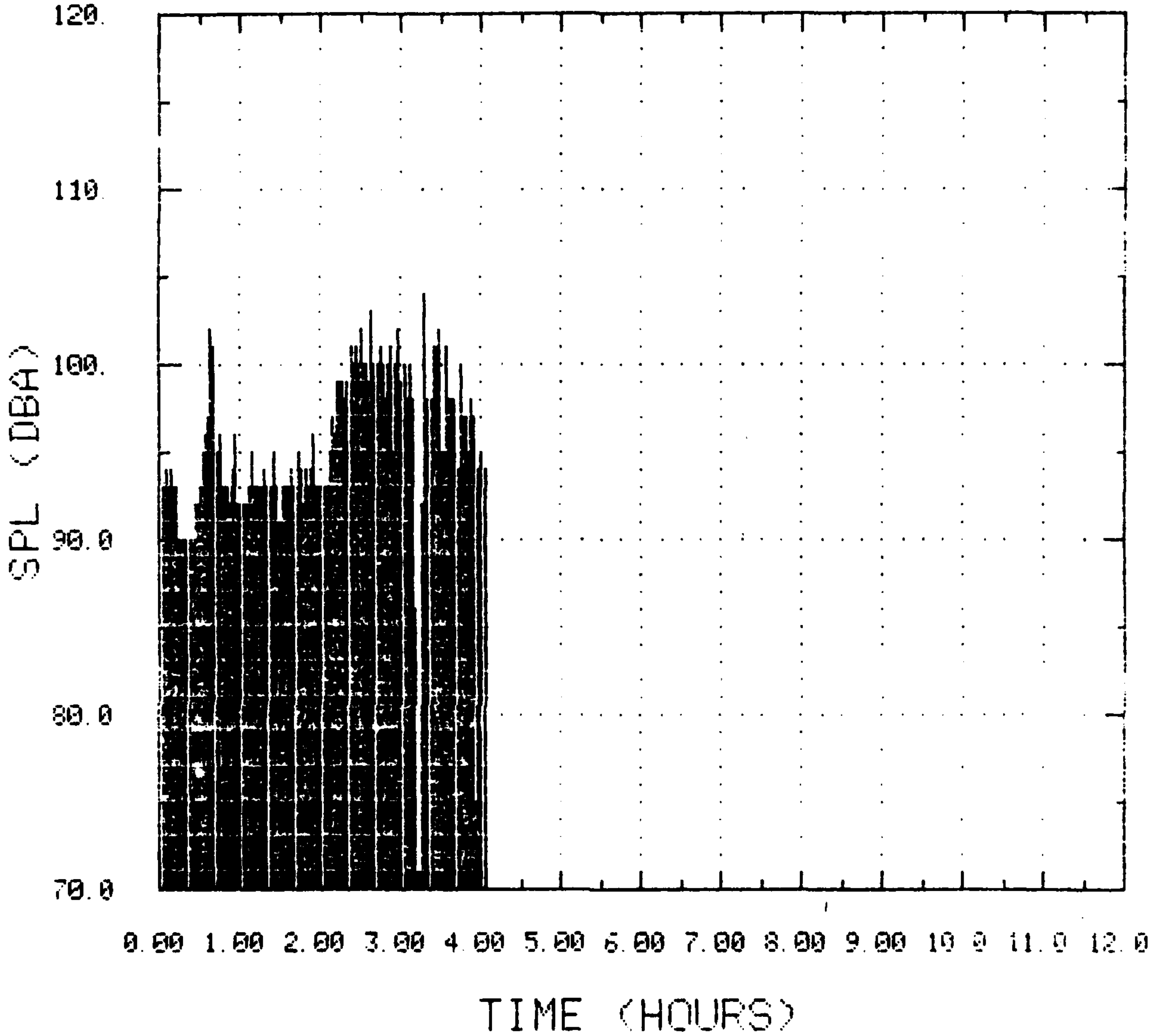

FIGURE B-52. **NOISE DOSIMETRY ON OILER**
(Taken during laden voyage)
Sample No. TX-14B

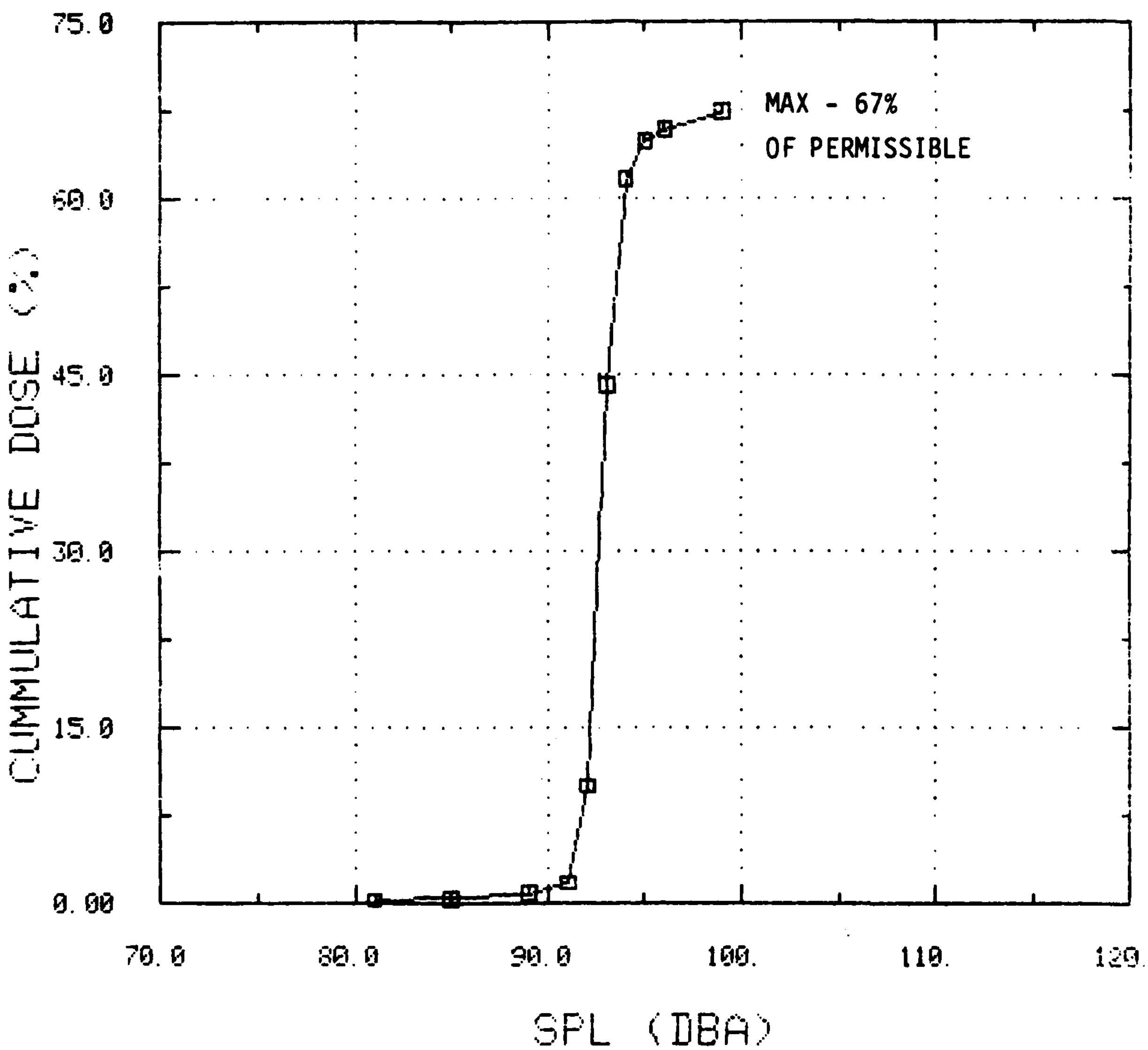

FIGURE B-51. **CUMULATIVE DOSE RECORDED ON OILER**
Sample No. TX-14A

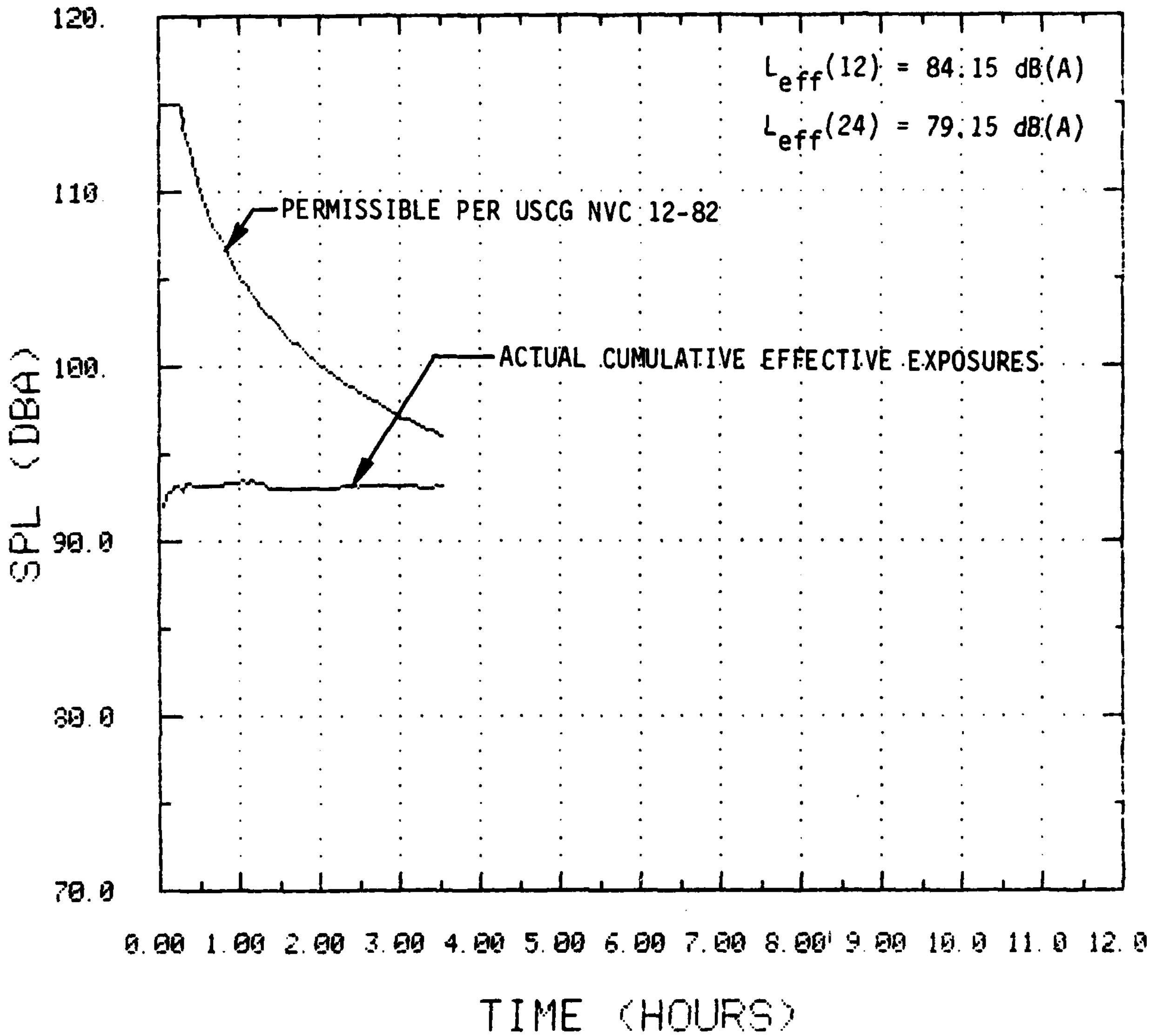

FIGURE B-50. **CUMULATIVE EFFECTIVE EXPOSURE ON OILER**
Sample No. TX-14A

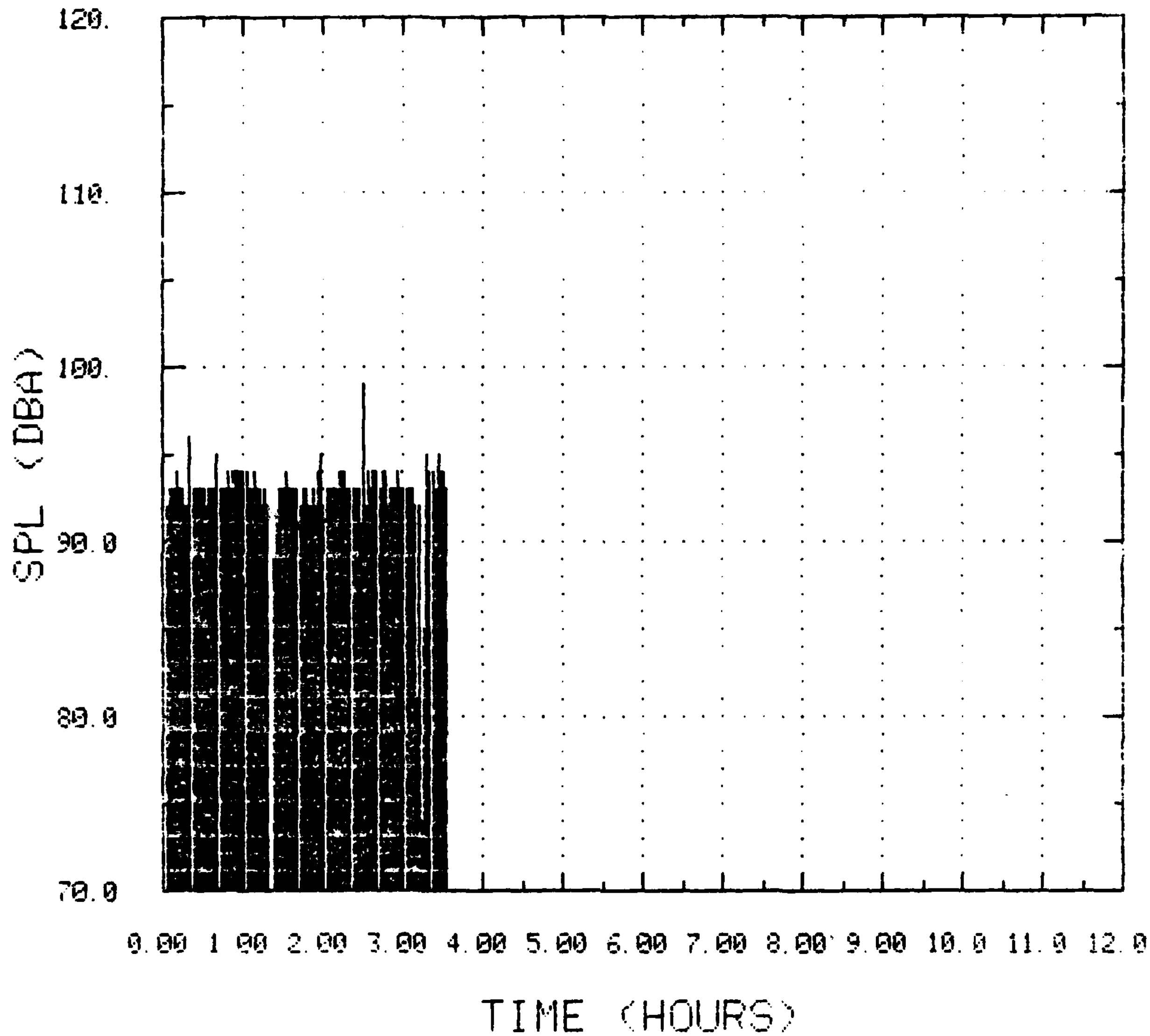

FIGURE B-49. NOISE DOSIMETRY ON OILER
(Taken during laden voyage)
Sample No. TX-14A

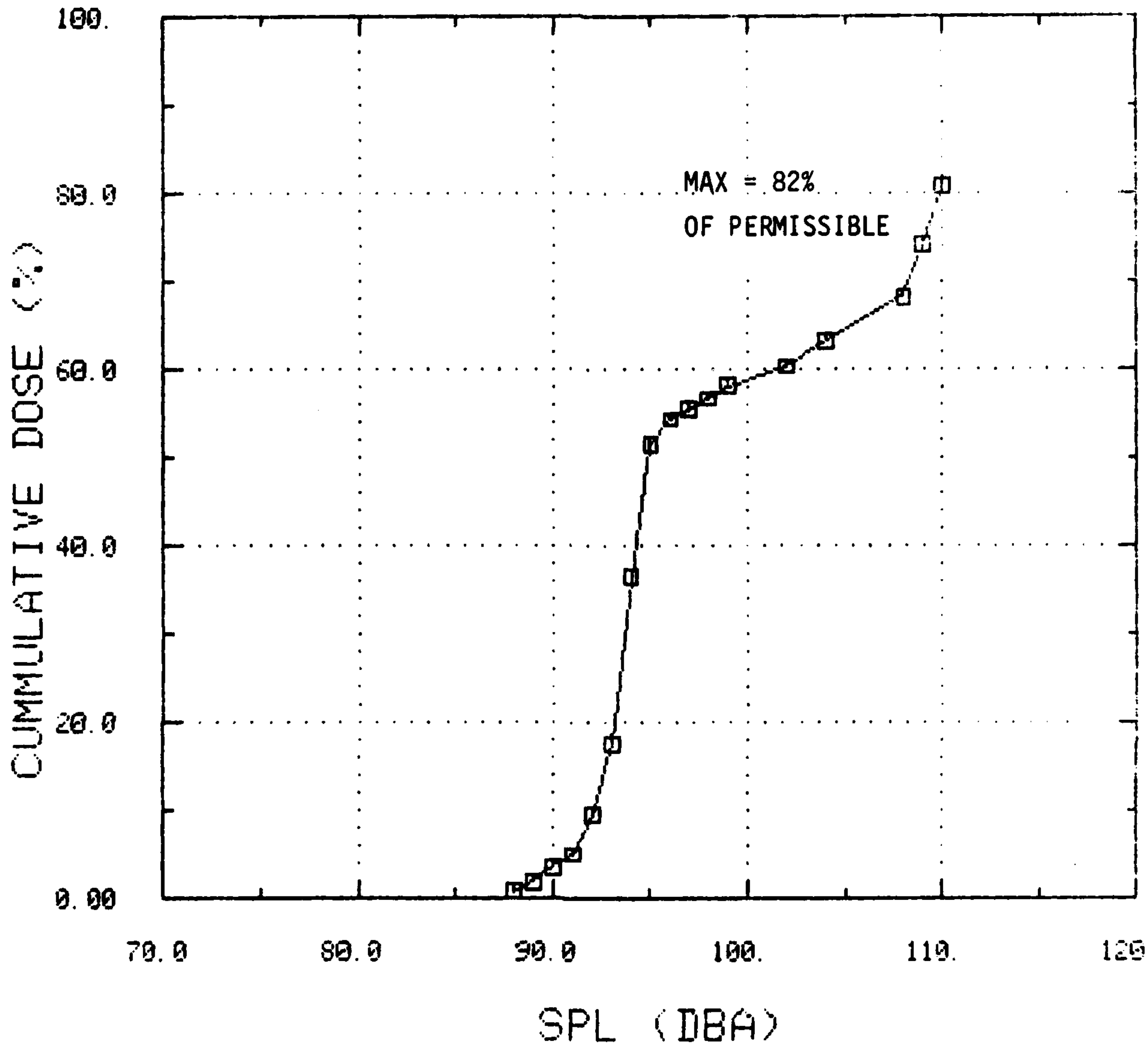

FIGURE B-48. **CUMULATIVE DOSE RECORDED ON ASSISTANT ENGINEER Sample No. TX-13B**

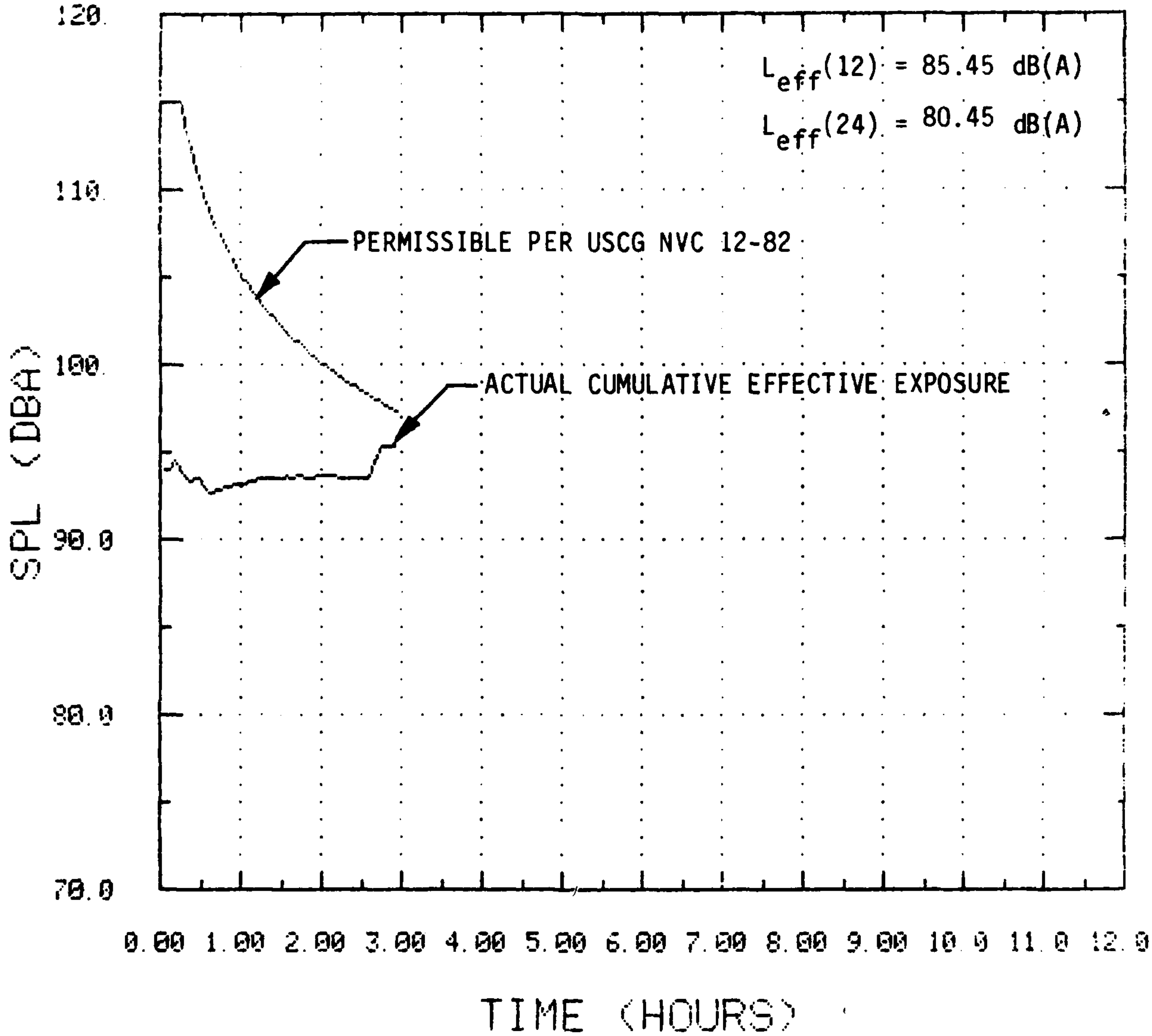

FIGURE B-47. **CUMULATIVE EFFECTIVE EXPOSURE ON ASSISTANT ENGINEER Sample No. TX-13B**

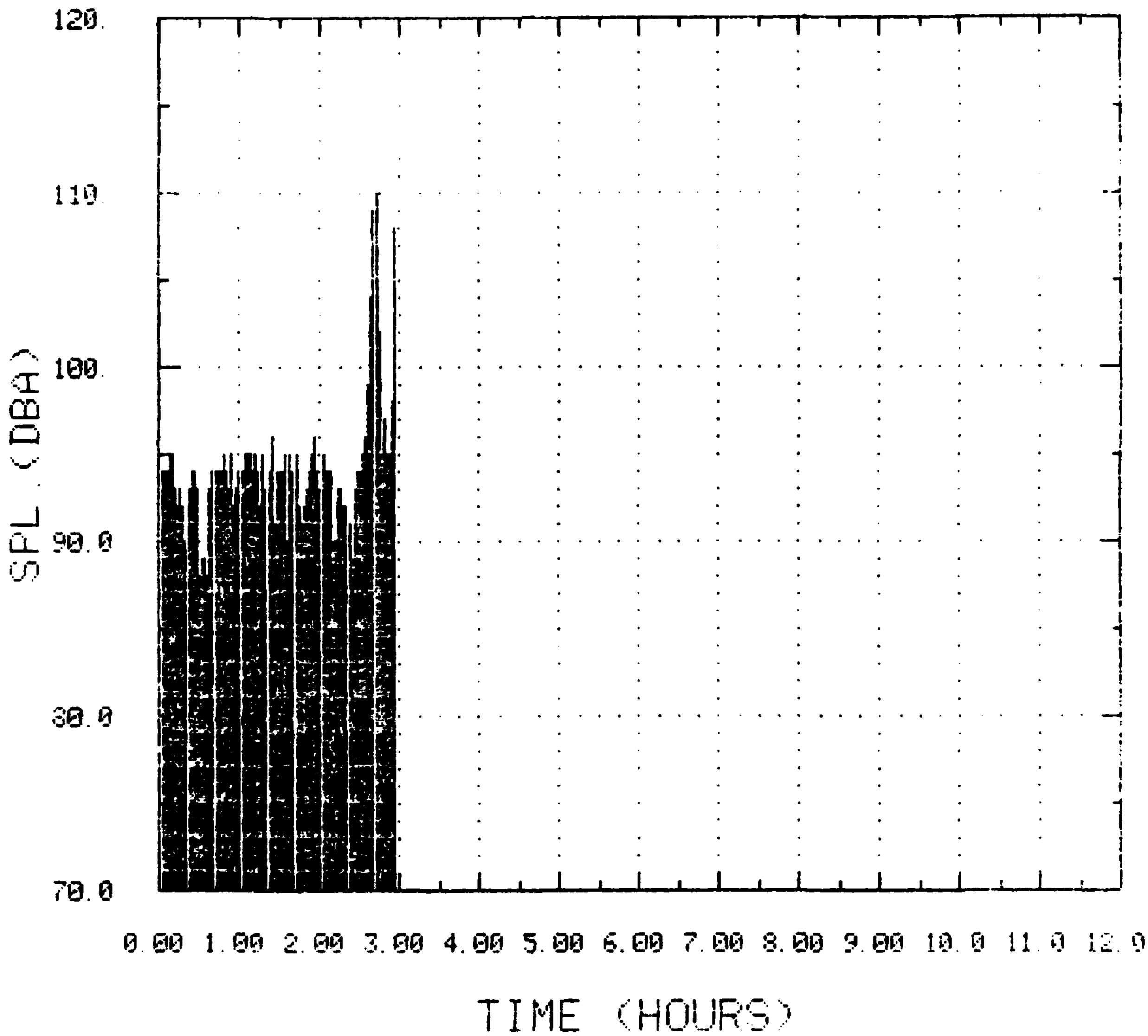

FIGURE B-46. NOISE DOSIMETRY ON ASSISTANT ENGINEER
(Taken during laden voyage)
Sample No. TX-13B

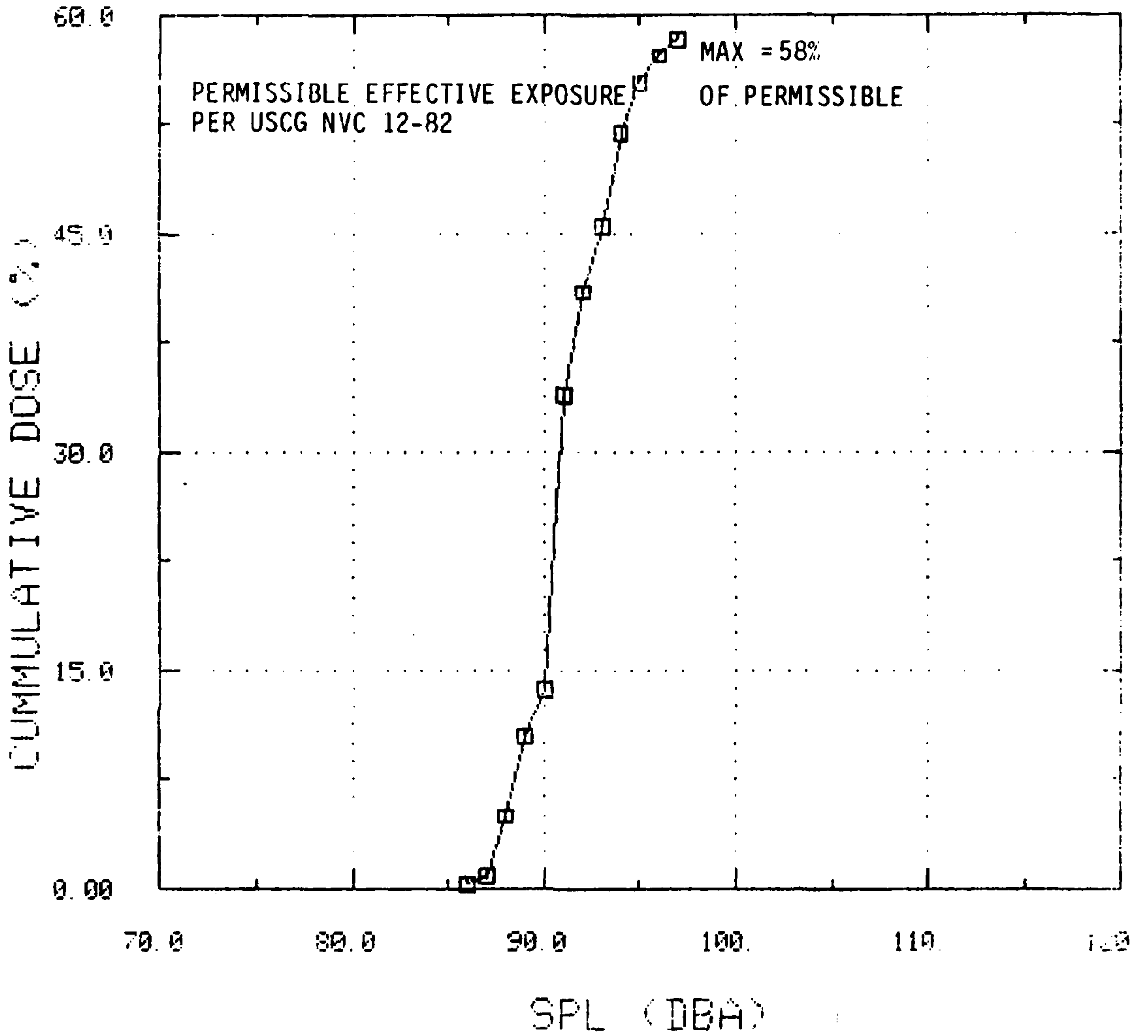

FIGURE B-45. **CUMULATIVE DOSE RECORDED ON ASSISTANT ENGINEER Sample No. TX-13A**

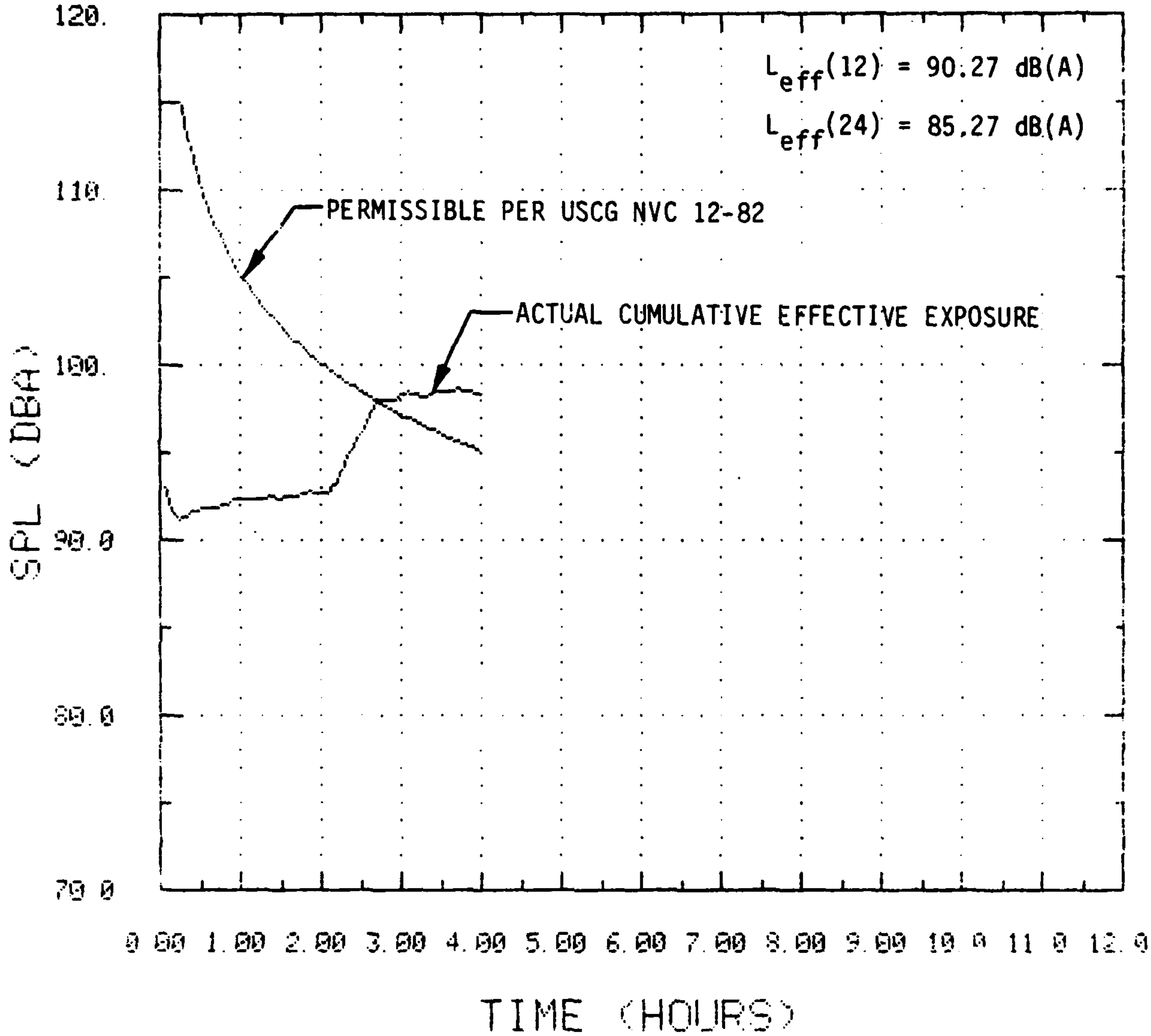

FIGURE B-59. **CUMULATIVE EFFECTIVE EXPOSURE ON ASSISTANT ENGINEER**
Sample No. TX-15B

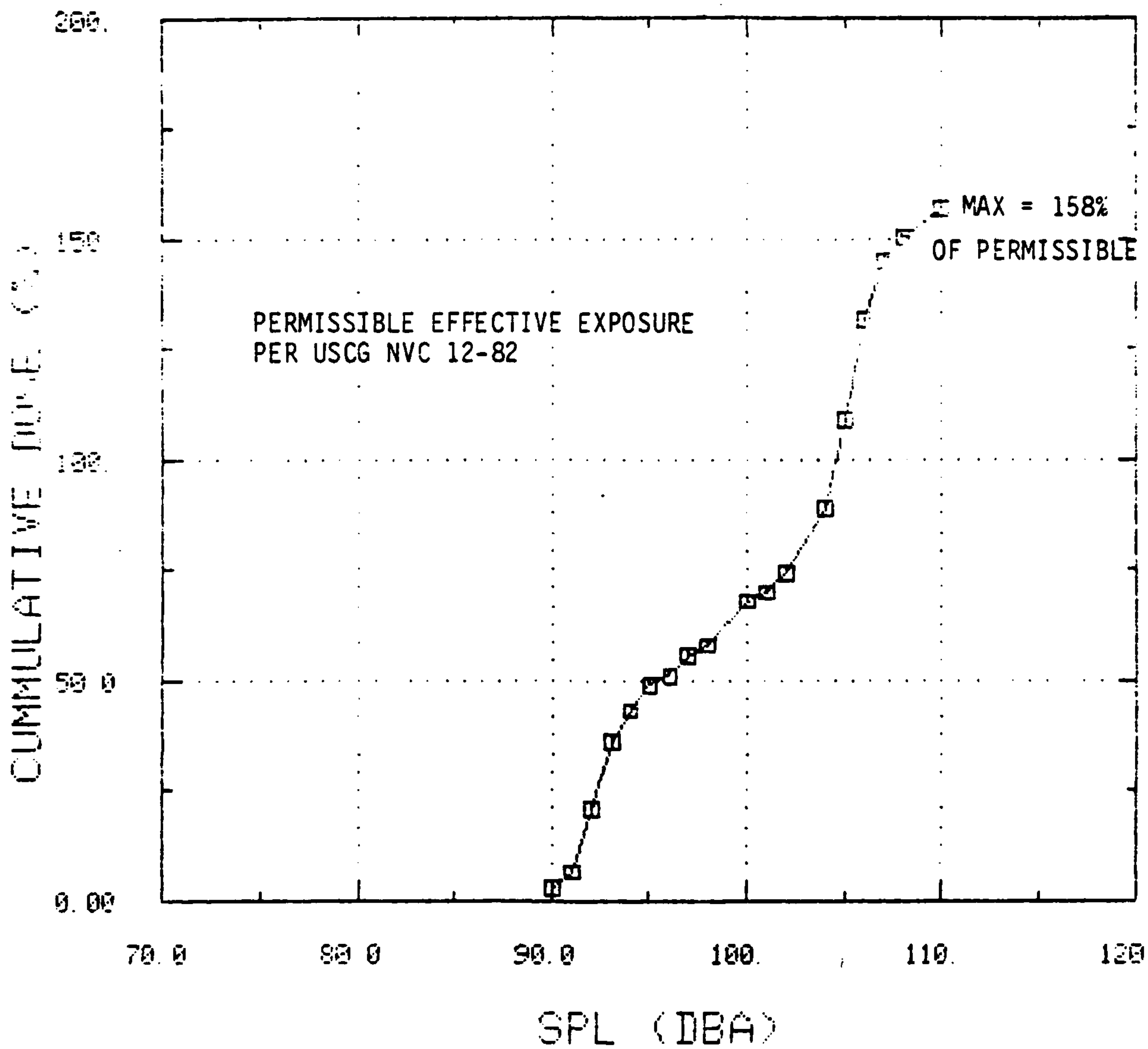

FIGURE B-60. **CUMULATIVE DOSE RECORDED ON ASSISTANT ENGINEER Sample No. TX-15B**

APPENDIX C

VOYAGE REPORT - VOYAGE 3

VOYAGE 3 REPORT OUTLINE

I. Vessel Description

II. Deck House Configuration and Ventilation

III. Cargo Storage and Transfer

IV. Deck Watch Composition and Work Schedule

V. Trip Overview and Objectives

VI. Sampling Strategy and Sample Analysis

VII. Activities and Occupational Exposures of Various Deck Department Crewmen

- VII.1 Product Loading
- VII.2 Product Discharge
- VII.3 Ballasting
- VII.4 Tank Cleaning
- VII.5 Tank Entry

VIII. Miscellaneous Observations

I. Vessel Description

I.1 Dimensions

- o Length overall, 672'
- o Breadth molded, 89'

I.2 Tonnage

- o Summer draft - 36,100 DWT

I.3 Propulsion

- o Steam - 15000 hp

I.4 Cargo Tanks

- o 30 Grade "A" cargo tanks
- o 4 Grade "A" or "B" cargo deck tanks
- o 6 Segregated ballast/Grade "B" cargo tanks (Tanks 2P/S, 4P/S and 5P/S)

I.5 Cargo Pumps

- o Grade "A" Tanks - (30) Independent deep well pumps ranging from 250-1000 gpm
- o Deck Tanks - (4) Independent pumps each 200 gpm
- o Segregated Ballast/Grade "B" Tanks - (2) Deepwell pumps at 3300 gpm each, one for port tanks and one for starboard tanks

I.6 Cargo Loading

- Open drop, short loading and full loading, both shore and ship-stop

I.7 Cargo Gauging Method

- Restricted gauging on (30) Grade "A" tanks
- Open gauging on (6) Ballast/Grade "B" cargo tanks and (4) deck tanks

I.8 Vapor Venting System

- Grade "A" cargo tanks had dedicated vent piping that originated at the expansion trunk and terminate at one of five B/3 mast risers. Each vent line had a P/V valve. In practice, however, this sytem was not used. Instead, tank venting was accomplished through slightly raised tank hatches.
- Ballast/Grade"B" tanks had only standard ullage ports atop the expansion trunk hatches for venting and no P/V valves.
- Deck tanks had separate vent lines.
- One of the cargos, styrene, was vented by vapor return back to shore.

I.9 Tank Cleaning Method

- Hot and cold water washing with portable Butterworth machines.
- Gas freeing accomplished by a portable air driven Coppus blowers, or central "Kathabar" blower (4500 CFM) that discharged into the tanks through the open drop of the cargo piping.

II. Deckhouse Configuration and Ventilation

II.1 Deckhouse Configuration

The deckhouse consisted of four levels:

- o Main Deck - Galley, crew and officer's mess, ship's office and unlicensed crewmen's quarters.
- o 2nd Level - Licensed crewmen, the Bosun and Pumpman, and contained the officer's lounge.
- o 3rd Level - Captain's and Radio Officer's quarters and office, and the ship's gyro room.
- o 4th Level - Navigation bridge.

Access to the deckhouse could be accomplished on all levels. On the main deck, two pairs of double doors were located in front of the deckhouse. These doors were not the standard marine type, water-tight doors. Three standard marine doors were located on the 2nd level. Two were on the sides and one in the rear of the deckhouse. Similar type access ways were located on the third and fourth level.

II.2 Deckhouse Ventilation

Conditioned air was provided to all levels by a central heating and cooling unit located in the rear of the deckhouse on the 2nd level. Fresh air vents were located near the unit and were open to the ambient atmosphere during the entire voyage.

III. Cargo Description and Transfer

A total of 16 different pure chemicals and solvents were handled on this voyage. They were contained in 33 of the 34 cargo tanks. One cargo tank, 1C, was empty for the entire voyage. Dirty ballast was being carried in the six ballast tanks upon arrival to the loading port. The ballast was "dirty" because the tanks had previously carried Naphtha and had not been cleaned prior to ballasting. The cargo and ballast storage plan is shown in Table I. For those chemicals having a CHRIS abbreviation, one is shown in the parentheses next to the chemical.

Also shown in Table I, is the type of cargo transfer that occurred at the loading port. Both loading and discharge of cargo were observed. When the ship arrived, 13 of the tanks were laden with product. Six of these tanks were off-loaded at the port. The other seven tanks were emptied at one of the discharge ports on the East Coast. All in all, a total of 21 tanks were loaded including the back loading of product into one of the six tanks that were discharged at the loading port. Most of the tanks were loaded to nearly full capacity except for seven which were short loaded between 33% to 72% of their capacity.

All products on board after leaving the loading port were subsequently discharged to three terminals and one barge on the East Coast.

IV. Deck Watch Composition and Work Schedules

The Deck Department was made up of four licensed and eleven unlicensed crewmen. The licensed crewmen consisted of the Chief Mate (C/M), Second Mate (2/M) and two Third Mates (3/M). Six able-body seamen (A/B), three ordinary seamen (O/S), a Bosun and a Pumpman comprised the unlicensed crew.

TABLE I. CARGO STORAGE AND TRANSFER AT LOADING PORT

Tank No.	Cargo	Transfer Code	Quantity (Gallons)	% Full
DKTK 1P	EA-E100 (EAL)	L	19141	97.2
DKTK 1S	Methanol (MAL)	D	19064	96.4
DKTK 2P	Methanol (MAL)	D	19180	61.8
DKTK 2S	EA-E100 (EAL)	L	14705	99.0
1A	1,1,1-Trichloroethane (TCE)	L	92134	87.7
1B	Ethylene Dichloride (EDC)	L	85267	42.5
1C	Empty	-	-	-
1D	Trichloroethylene (TCL)	L	43564	72.4
2A	Ethylene Glycol (EGL) (1)	D/L	342546	98.3
2B	Caustic (CSS)	D	165668	96.9
2C	Caustic (CSS)	D	166563	97.5
2D	Acetone (ACT)	L	447168	98.2
2E	Caustic (CSS)	D*	-	-
3A	Perchloroethylene (TTE)	L	291689	51.3
3B	Caustic (CSS)	D	107820	95.8
3C	Ethylene Glycol (EGL)	L	107820	95.8
3D	Propylene Glycol (PPG)	L	111562	97.7
3E	Caustic (CSS)	D*	-	-
3F	Caustic (CSS)	L	217392	96.7
3P	Styrene (STY)	L	718205	97.6
3S	Styrene (STY)	L	715585	97.2
4A	Voranol	L	125990	98.4
4B	Caustic (CSS)	D*	-	-
4C	Glycerine (GCR)	L	125888	98.1
4D	Lignin Liquor	D*	-	-
5A	1,1,1-Trichloroethane (TCE)	L	333919	98.2
5B	1,1,1-Trichloroethane (TCE)	L	331195	97.5
6A	Lignin Liquor	D*	-	-
6B	Lignin Liquor	D*	-	-
6P	Versene 100	L	130790	33.0
6S	Ethylene Glycol (EGL)	L	219165	55.4
7C	Lignin Liquor	D*	-	-
7P	Methylene Chloride (DCM)	L	150281	58.5
7S	Methylene Chloride (DCM)	L	133918	52.0
2P,2S	Dirty Ballast	D/L	-	-
4P,4S	Dirty Ballast	D/-	-	-
5P,5S	Dirty Ballast	D/-	-	-

(1) - Diethylene glycol was discharged prior to loading of EGL
L - Tank was loaded
D - Product was on board upon arrival at loading port and subsequently discharged at the same port
D* - Same as D except discharge was on the East Coast

All crewmen did the majority of their work in a 4-hour on, 8-hour off routine, with the exception of the C/M, the Bosun, and the Pumpman, These three individuals usually worked between 0800-1700 hours. Depending on whether the ship was in port or at sea, certain work activities required some of these individuals to work more than eight hours per 24-hour day.

The primary activity when the ship was in port was cargo transfer. The standard ship watch compliment for this activity consisted of one mate (excluding the C/M), two A/Bs and one O/S. The cargo transfer watch was four hours. The unlicensed crewmen seldom exceeded their two 4-hour watches during a 24 hour day. The 3/Ms, however, did exceed 8-hour workdays by standing a day or barrel watch (0800-1700) in addition to their normal 4-hour watches. The day watch rotated to the other 3/M the next time the ship was in port. Although the 2/M is not included in this rotation, he worked for a period of time exceeding his two 4-hour watch periods.

Between the hours of 1600-0800, the four man watch team was assisted by two shore based mates called Port Relief Officers (PRO), who each stand an 8-hour watch. These same PROs are available during the next 16-hour night period provided the ship is still in port.

The C/M was also involved in the cargo transfer operation. Because he had overall responsibility for cargo transfer, the C/M was usually on call during the entire time while the ship was in port. At the loading port, he acted in a supervisory capacity, periodically canvasing the Mates' tank ullage readings to assure that the ship maintained the proper list and trim. Occasionally, he did perform tank gauging. At the discharge port, however, he became more involved in the cargo transfer by stripping a number of the tanks.

Other activities observed while the ship was in port were transfer and gauging of ballast and the loading of stores. These activities usually are handled by the Pumpman and the Bosun, respectively. In most cases, the A/Bs and O/Ss on cargo transfer watch will assist the Bosun in securing the stores to the deckhouse. In addition to gauging ballast tanks, the Pumpman was involved in cargo tank gauging during the product discharge. He was also responsible for the startup and periodic checking of the ship's discharge pumps while the ship was at the discharge port.

When the ship was at sea, the four man cargo watch team stands navigation watch. During navigation watch, the Mate was assisted by one of the A/Bs (quartermaster), who steered the ship at the direction of the Mate. The other unlicensed crewmen were on standby to relieve the quartermaster when he took his break. During the night hours, the two reliefs also stand a bow watch. During daylight hours and when not on watch, the unlicensed crew members worked overtime performing various deck work tasks at the direction of the C/M. The 2/M and two 3/Ms, however, spent their entire work periods in the ship's wheelhouse.

During this voyage, the deck work activities primarily involved gas freeing the ship in preparation for drydock for repairs and biennial inspection. These activities commenced soon after the ship left the loading terminal with the cleaning of the dirty ballast tanks. After the bulk of the products were off-loaded at the next to last discharge port, tank cleaning resumed until all tanks and enclosed spaces were ventilated.

The Bosun, C/M, and majority of the ship's A/Bs and O/Ss were involved in tank cleaning. The Bosun and C/M supervised the operation. Some of the tanks were washed prior to gas freeing while others required only ventilation. Tanks were entered for testing and manual cleaning.

V. Objective and Trip Overview

At the onset of this test, it was apparent that the selection of only two individual Deck Department crewmen for documentation and exposure monitoring would result in missing many other pertinent work activities involving other crewmen. Consequently, rather than concentrating on certain individuals for the entire voyage, the objective was expanded to observe and monitor as many work activities as possible that involved potential exposures to the chemical cargos of interest.

The work activities performed on this voyage were generally similar to those carried out on other voyages of this ship with one exception. Because the ship was scheduled to go into dry dock for its biennial inspection, more extensive tank cleaning was performed. This included tank entry. A summary of the major activities observed and monitored on this voyage are shown in Table II.

TABLE II. MAJOR DECK WORK ACTIVITIES

Period Cargo Tank Gauging - Restricted, Loading
Tank Top-off Gauging - Restricted, Loading
Period Ballast Tank Gauging - Open, Ballasting
Hose Hookup and Disconnect
Periodic Cargo Tank Gauging - Restricted, Discharge
Tank Stripping
Tank Washing and Ventilation
Tank Entry for Inspection
Tank Entry for Mucking

The entire voyage observation lasted 15 days. The sequence of voyage segments is shown in Figure 1.

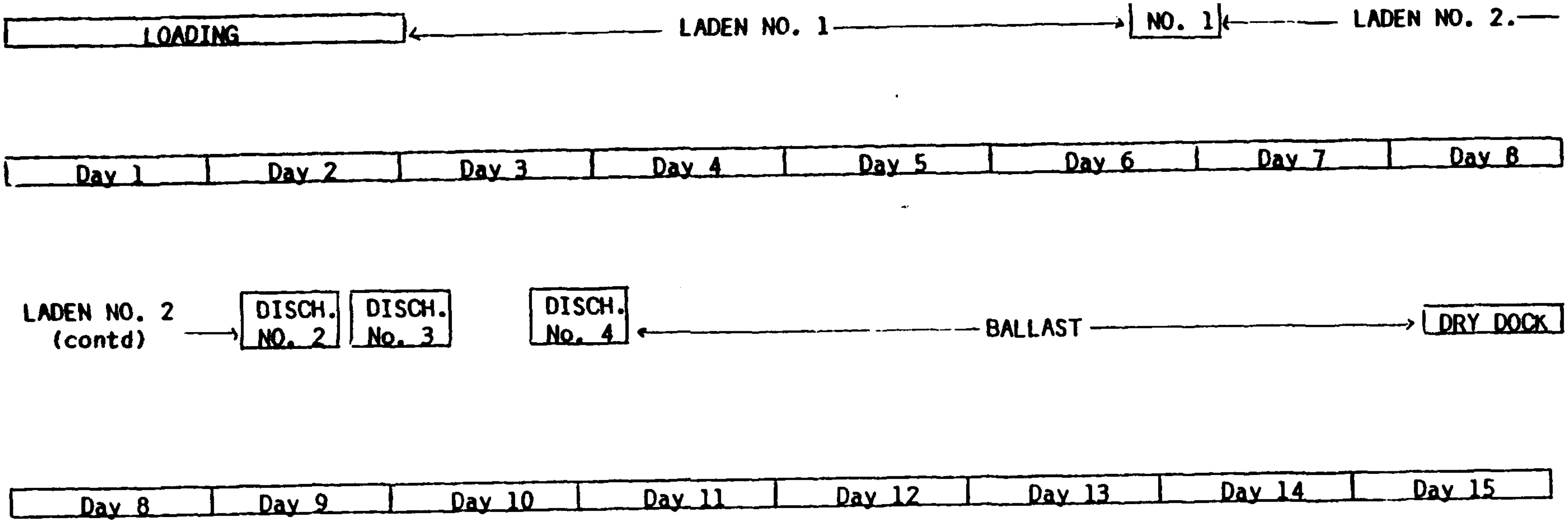

FIGURE 1. SEQUENCE AND DURATION OF MAJOR VOYAGE SEGMENTS

Sampling Strategy and Sample Analysis

Nine of the chemicals transported on the ship were chosen for ipational exposure monitoring. These chemicals were chosen because they ı NIOSH sampling and analysis procedures and published exposure limits. isting of these chemicals is shown in Table III.

TABLE III. RECOMMENDED NIOSH SAMPLING METHODS AND TLV LIMITS OF THE SELECTED CHEMICALS

Chemical	NIOSH Sampling Method No.	TLV-TWA(1) (ppm)	TLV-STEL (1)
\cetone (ACT)	S1	750	1000
l,1,1-Trichloroethane (TCE)	S328	350	450
1ethylene Chloride (DCM)	S329	100	500
Trichloroethylene (TCL)	S336	50	150
Perchloroethylene (TTE)	S335	50	-
Ethylene Dichloride (EDC)	S122	10	15
Styrene (STY)	S30	50	100
NAPHTHA (STODDARD) (NSS)	S382	100	200
Ethylene Glycol (EGL)	S338	50(vapor)	-

Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, American Conference of Governmental Industrial Hygienist, 1983.

The main reason for not monitoring the remainder of the chemicals /or solvents was due primarily to the absence of sampling and analysis cedures for these compounds. This was the case for EA-E100, Propylene col, Lignin Liquor, Versene 100 and Voranol. Some of the chemicals, ever, did have published procedures but due to circumstances were not itored. These are summarized below:

o Methanol - Small quantities of methanol were carried in the deck tanks. After discharge, the tanks were washed, but not ventilated or entered. As such, the potential for exposure to methanol vapors was judged to be minimal.

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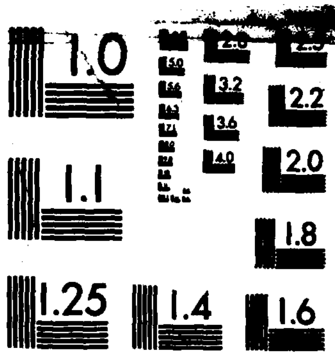

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

- Caustic Soda - Primary occupational exposure route is through dermal contact with bulk liquid.

- Glycerine - Neither vapor nor mist are likely to be encountered during standard ship transfer procedures.

Both active and passive dosimeters were used. The active dosimeters included large and small charcoal tubes. The passive dosimeters were Dupont G-AA and G-BB badges. The adsorbent used for monitoring of EGL vapors was silica gel. All tube and badge samples were analyzed by an AIHA accredited laboratory.

The results of the sampling effort are summarized in Tables IV through VI. Table IV contains the flow rate, time, and ambient temperature conditions for each sample. A total of 107 tubes and badge samples were collected including 24 passive badges (samples whose sample number begins with 6) and 83 tubes. Three of the sample tubes contained silica gel to monitor exposure to EGL vapors. The remaining 80 tubes comprised the charcoal tube samples (75 small and 5 large). All active samples were collected at a nominal flow rate of 0.2 Liter/min.

Table V illustrates the chemical desorption efficiencies (DE) for the charcoal tubes and badges. Manufacturer's DEs were used for the passive badges whereas the DEs for the tubes were determined by the AIHA laboratory that analyzed the unknown samples. Because EGL was not detected in the unknown samples, its' desorption efficiency was not determined.

The information from Table IV and V along with the weight analysis of the samples was inserted into one of the following expressions used to calculate ambient exposure concentration.

TABLE IV. OCCUPATIONAL AND AREA SAMPLING CONDITIONS

Sample No.	Pump No.	Flow Rate (L/min)	Average Temperature (°F)	Sample Duration (min.)
H-8	M12	0.199	84.	97.
MC-17	M5	0.204	79.	227.
03-P18	M12	0.199	79.	149.
MC-19	M5	0.204	78.	36.
01-P18	9A	0.191	76.5	266.
TX-104	M12	0.199	76.5	132.
SB-36	M3	0.201	75.	21.
SB-16	M10	0.203	75.	221.
H-9	M11	0.202	75.	32.
62799	-	-	75.	24.
03-P19	M3	0.201	75.	28.
SB-38	M3	0.201	75.	14.
SB-98	M11	0.202	85.	49.
H-11	M3	0.201	81.5	129.
MC-13	M10	0.203	83.	44.
MC-37	9A	0.191	80.	296.
01-P14	P5	0.196	77.	170.
MC-11	M5	0.204	77.	134.
MC-18	M10	0.203	77.	130.
MC-12	M3	0.201	80.	95.
CG-2018	2A	0.194	80.	77.
MC-20	M3	0.201	80.	64.
SB-18	2A	0.194	80.	50.
CG-2019	M12	0.199	85.	149.
X-1	M3	0.201	85.	132.
02-P20	2A	0.194	85.	57.
02-P17	M11	0.202	88.	74.
X-10	M5	0.204	88.	90.
CG-2017	2A	0.194	88.	50.
X-4	M10	0.203	77.	34.
02-P12	M11	0.202	77.	17.
63778	-	-	77.	15.
CG-2015	M11	0.202	77.	11.
SB-25	M11	0.202	74.5	181.
X-7	M10	0.203	74.5	55.
CG-2020	P1	0.198	72.	4.
X-3	2A	0.194	74.5	10.
62745	-	-	72.	9.
DM-7	P1	0.190	68.5	183.
62743	-	-	68.5	162.
DM-3	M11	0.202	65.	19.
DM-4	P1	0.198	62.	16.
DM-8	M-11	0.202	62.	11.
X-2	P1	0.198	65.	92.

TABLE IV. OCCUPATIONAL AND AREA SAMPLING CONDITIONS (cont'd)

Sample No.	Pump No.	Flow Rate (L/min)	Average Temperature (°F)	Sample Duration (min.)
DM-6	M-11	0.202	72.	82.
DM-2	P6	0.200	72.	82.
X-6	2A	0.194	72.	40.
X-9	2A	0.194	75.	119.
DM-9	4A	0.198	75.	116.
DM-5	4A	0.198	66.5	123.
X-5	P7	0.208	65.	203.
DM-1	P2	0.204	66.5	130.
62746	-	-	66.5	116.
62040	-	-	65.	119.
DM-17	4A	0.198	65.	112.
64426	-	-	65.	77.
DM-13	P2	0.204	68.	84.
X-19	P7	0.208	58.	215.
X-14	M9	0.199	58.	225.
64421	-	-	58.	59.
64422	-	-	58.	21.
64424	-	-	58.	1.
X-100	P3	0.150	58.	65.
X-13	P7	0.208	58.	177.
MC-14	M7	0.205	65.	154.
62039	-	-	65.	154.
X-12	M9	0.199	65.	65.
62038	-	-	65.	57.
DM-15	P2	0.204	65.	66.
DM-16	4A	0.198	65.	66.
08-P8	M2	0.196	65.	445.
SB-2	P4	0.207	65.	115.
64423	-	-	65.	107.
62037	-	-	65.	128.
DM-19	4A	0.198	65.	84.
DM-11	P2	0.204	65.	85.
X-15	M9	0.199	65.	43.
L-7	P4	0.207	65.	40.
DM-14	M1	0.201	65.	18.
64425	-	-	65.	34.
X-16	M7	0.205	65.	2.
DM-20	M1	0.201	67.	6.
68996	-	-	67.	12.
X-23	M7	0.205	67.	2.

TABLE IV. OCCUPATIONAL AND AREA SAMPLING CONDITIONS (concluded)

Sample No.	Pump No.	Flow Rate (L/min)	Average Temperature (°F)	Sample Duration (min.)
DM-12	M1	0.201	67.	2.
X-27	M7	0.205	67.	16.
62035	-	-	67.	9.
DM-30	M-8	0.199	67.	15.
SB-8	C	0.202	75.	434.
DM-26	M4	0.198	75.	16.
62034	-	-	75.	18.
X-26	M7	0.205	75.	15.
62033	-	-	75.	15.
X-18	M9	0.199	75.	43.
X-25	M7	0.205	75.	16.
X-35	M7	0.205	68.	14.
62032	-	-	68.	14.
X-21	M9	0.199	68.	26.
X-8	M9	0.198	68.	11.
63839	-	-	68.	11.
X-40	M6	0.197	68.	10.4
63837	-	-	68.	10.4
DM-41	M4	0.198	68.	44.
62790	-	-	68.	44.
DM-47	M8	0.199	68.	45.
62797	-	-	68.	45.
DM-40	M4	0.198	68.	48.

TABLE V. DESORPTION EFFICIENCY OF SAMPLING MEDIA

Passive Charcoal Dosimeters

Compound	η, Desorption Efficiency(1)	Sampling Rate (cm3/min)(1)(2)
Acetone (ACT)	0.67	38.2
1,1,1-Trichloroethane (TCE)	1.01	30.2
Methylene Chloride (DCM)	0.93	34.6
Trichloroethylene (TCL)	0.98	32.6
Perchloroethylene (TTE)	0.98	25.5
Ethylene Dichloride (EDC)	0.94	28.9
Styrene (STY)	0.89	29.6
Naphtha (NSS)	1.00	26.5

Charcoal Sampling Tubes (3)

	Small Tubes		Large Tubes	
Compound	0.5 TWA	2 TWA	0.5 TWA	2 TWA
Acetone (ACT)	81.6	92.6	69.8	83.2
1,1,1-Trichloroethane (TCE)	97.4	89.6	113.7	99.8
Methylene Chloride (DCM)	93.2	--	113.2	--
Trichloroethylene (TCL)	96.8	98.0	111.6	103.3
Perchloroethylene (TTE)	96.2	90.4	112.7	103.7
Ethylene Dichloride (EDC)	93.4	72.9	104.4	97.6
Styrene (STY)	89.0	94.0	89.0	84.4
Naphtha (NSS)	105.0	104.0	107.0	106.0

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(1) Manufacturer's data
(2) Sampling rate is for DuPont GBB Badge or GAA Badge with one cover off
(3) Experimentally determined data at the two concentration levels noted

- Adsorbent Tubes

$$C\ (\text{ppm}) = \frac{W_c}{\eta Q t}\ \frac{24.45}{MW} \left(\frac{T + 273}{298}\right) \frac{760}{P}$$

where

W_c = cumulative weight of analyte on the tube corrected for blank, µg

η = desorption efficiency as a decimal

Q = sampling flow rate, LPM

t = sample duration, min

MW = analyte molecular weight

T = sampling temperature, °C

p = sampling barometric pressure, mm Hg

- Passive Dosimeters

$$C\ (\text{ppm}) = \left(\frac{W_{CF} + 2.2\ W_{CB}}{\eta (SR)\ T}\right) \frac{24.45}{MW} \left(\frac{T + 273}{298}\right) \frac{760}{P}$$

where

W_{CF} = weight of analyte on exposed front strip corrected for blank, ng

W_{CB} = weight of analyte on backup strip corrected for blank, ng

SR = passive sampling rate, cm^3/min.

Other quantities are as defined for the adsorbent tubes. The pressure correction was not applied as all samples were collected at sea level conditions.

Table VI summarizes the calculated occupational exposure and area concentrations monitored during this voyage. These concentrations are listed by sample number, personnel upon whom the sample was taken and the general activity that was performed during monitoring. Area sample locations are also included. Concentrations with a greater than (>) sign next to them signify that the actual concentration value may be more than indicated since the back section of the sampling media contained in excess of 10% of the amount collected on the front section for that sample.

VII. Activities and Occupational Exposures of Various Deck Department Crewmen

VII.1 Product Loading

Following hose hookup, the sequence of events during loading was as follows.

- Approximately one foot of cargo ("heel") was pumped into the tank, then the flow was stopped.
- A deck employee retrieved a dropline sample of the "heel" through the tank expansion trunk and took it to shore for lab analysis.
- If the sample met specification, pumping was resumed at the approval of the mate on watch.
- Cargo continued to be loaded until the required quantity was onboard. The loading of some cargoes was stopped prior to the finish of loading and then resumed until finished.
- Termination of loading was accomplished by a "shore" stop on some chemicals and "ship" stop on others.

TABLE VI. CALCULATED AMBIENT VAPOR EXPOSURE CONCENTRATION, PPM

Voyage Day	Sample No.	Worker	Activity	ACT	TCE	DCM	TCL	TTE	EDC	STY	NSS	EGL
1	H-8	2/M	Restricted Gauging (Loading)	--	--	0.2	--	--	--	ND	--	--
1	MC-17	3/M-1	Restricted Gauging (Loading)	ND	ND	ND	--	ND	ND	ND	--	--
1	03-P18	2/M	Restricted Gauging (Loading)	7.7	ND	--	--	--	--	ND	--	--
1	MC-19	3/M-1	Tank Top-Off of 2D (ACT)	176.6	--	--	--	ND	--	ND	--	--
1	01-P18	AREA	Near 3C (EGL) Standpipe	--	--	--	--	--	--	--	--	ND
1	TX-104	PRO-1	Restricted Gauging (Loading)	--	--	--	--	--	--	ND	--	--
2	SB-36	PRO-1	Tank Top-Off of 5A (TCE)	--	58.4	--	--	--	--	--	--	--
2	SB-16	3/M-2	Restricted Gauging (Loading)	--	--	0.3	--	0.1	ND	ND	--	--
2	H-9	AREA +	Near Styrene Tank Standpipe	--	--	--	--	--	--	ND	--	--
2	62799	AREA	Near Styrene Tank Standpipe	--	--	--	--	--	--	15	--	--
2	03-P19	PRO-2	Tank Top-Off of 3S (STY)	--	--	--	--	--	--	7.5	--	--
2	SB-38	PRO-2	Tank Top-Off of 3P (STY)	--	--	--	--	--	--	6.6	--	--
2	SB-98	Pumpman	Open Gauging (Ballasting)	--	--	--	--	--	--	--	111.8	--
2	H-11	AREA	Near 5B (TCE) - 10' DW of Expansion Trunk	--	>154.5	--	--	--	--	--	--	--
2	MC-13	PRO-1	Restricted Gauging (Loading) & Tank Top-Off of 5B (TCE)	--	56.9	--	--	--	--	--	--	--
2	MC-37	AREA	Near 2A (EGL) Standpipe	--	--	--	--	--	--	--	--	ND
2	01-P14	AREA	Near 2A (EGL) Standpipe	--	--	--	--	--	--	--	--	ND
2	MC-11	PRO-1	Tank Top-Off of 1A (TCE)	--	28.8	--	--	--	--	--	--	--
2	MC-18	AREA	Near 1A (TCE) Standpipe & Expansion Trunk	--	>123.0	--	--	--	--	--	--	--
3	MC-12	C/M	Tank Cleaning (Washing)	--	--	--	--	--	--	--	49.9	--
3	CG2-018	Bosun	Tank Cleaning (Washing)	--	--	--	--	--	--	--	36.9	--
3	MC-20	C/M	Tank Cleaning (Washing)	--	--	--	--	--	--	--	38.5	--
3	SB-18	Bosun	Tank Cleaning (Washing)	--	--	--	--	--	--	--	35.8	--
4	CG2-019	Bosun	Tank Cleaning (Ventilation)	--	--	--	--	--	--	--	>89.8	--
4	X-1	O/S-1	Tank Cleaning (Washing)	--	--	--	--	--	--	--	23.0	--
4	02-P20	O/S-2	Tank Washing (Ventilation)	--	--	--	--	--	--	--	18.0	--
4	02-P17	SwRI-1	Tank Washing (Ventilation)	--	--	--	--	--	--	--	3.7	--

ND = Not Detected
\+ = Parallel active and passive sample

TABLE VI. CALCULATED AMBIENT VAPOR EXPOSURE CONCENTRATION, PPP (CONT'D)

Voyage Day	Sample No.	Worker	Activity	ACT	TCE	DCM	TCL	TTE	EDC	STY	NSS	EGL
4	X-10	O/S-1	Tank Cleaning (Wash & Vent)	--	--	--	--	--	--	--	7.8	--
4	CG2-017	O/S-3	Tank Washing (Ventilation)	--	--	--	--	--	--	--	14.0	--
9	X-4	A/B-1	Hose Connect	--	--	--	--	--	--	ND	--	--
9	02-P12	A/B-2	Hose Connect	--	--	--	--	--	--	ND	--	--
9	63778	AREA	Loading Manifold	--	--	--	--	--	--	4.5	--	--
9	CG2-015	A/B-2	Hose Connect	--	--	--	--	--	--	ND	--	--
9	SB-25	2/M	Restricted Gauging (Discharge)	--	--	--	--	--	--	ND	--	--
9	X-7	Pumpman	Restricted Gauging (Discharge)	--	--	--	--	--	--	ND	--	--
9	X-3	A/B-4	Hose Disconnect	--	--	--	--	--	--	ND	--	--
9	CG2-020	A/B-3	Restricted Gauging (Discharge)	--	--	--	--	--	--	ND	--	--
9	62745	AREA	Near Loading Manifold	--	--	--	--	--	--	9.8	--	--
9	DM-7	3/M-1	Restricted Gauging (Discharge)	--	--	--	--	--	--	ND	--	--
9	62743	PRO-2	Restricted Gauging (Discharge)	--	--	--	--	--	--	0.9	--	--
10	DM-4	C/M	Tank Stripping	--	--	--	--	--	--	5.8	--	--
10	DM-3	C/M+3/M-2	Tank Stripping	--	--	--	--	--	--	ND	--	--
10	DM-8	A/B-1	Hose Disconnect	--	--	--	--	--	--	12.9	--	--
10	X-2	2/M	Tank Sampling	ND	0.3	--	0.3	0.2	0.1	ND	--	--
10	DM-6	A/B-1	Hose Connect	ND	9.9	2.8	ND	0.2	0.2	ND	--	--
10	DM-2	A/B-2	Hose Connect	ND	ND	ND	ND	ND	ND	ND	--	--
10	X-6	A/B-3	Hose Connect	--	0.4	1.7	--	--	ND	--	--	--
10	X-9	A/B-4	Hose Connect	--	--	--	ND	--	0.1	--	--	--
10	DM-9	3/M-2	Restricted Gauging (Discharge)	ND	0.1	26.1	ND	ND	0.2	ND	--	--
10	DM-5	3/M-1	Restricted Gauging (Discharge)	ND	0.2	--	0.4	0.1	1.9	5.8	--	--
10	X-5	3/M-2	Restricted Gauging (Discharge)	--	--	ND	--	--	--	2.4	--	--
10	DM-1	C/M	Restricted Gauging (Discharge)	ND	ND	26.1	--	--	--	2.4	--	--
10	62746	PRO-3	Restricted Gauging (Discharge)	ND	--	--	--	--	--	8.1	--	--
10	62040	AREA	Near 3S (STY) Tank Ventilation	ND	--	--	--	--	--	50.1	--	--
10	DM-17	3/M-1	Restricted Gauging (Discharge)	ND	--	--	--	--	--	3.1	--	--
10	64426	PRO-3	Restricted Gauging (Discharge)	ND	--	--	--	--	--	0.7	--	--
10	DM-13	C/M	Restricted Gauging (Discharge)	ND	0.4	0.4	--	--	--	ND	--	--
11	X-19	3/M-2	Restricted Gauging (Discharge)	ND	--	--	--	0.2	--	ND	--	--
11	X-14	A/B-3	Hose Disconnect	ND	0.4	1.4	--	0.3	--	ND	--	--
11	64421	AREA	Near 2D (ACT)	ND	--	--	--	--	--	15.6	--	--

ND = Not Detected

TABLE VI. CALCULATED AMBIENT VAPOR EXPOSURE CONCENTRATION, PPM (CONT'D)

Voyage Day	Sample No.	Worker	Activity	ACT	TCE	DCM	TCL	TTE	EDC	STY	NSS	EGL
11	X-100	C/M	Stripping 2D (ACT), 3A (TTE)	ND	--	--	--	ND	--	7.1	--	--
11	64422	C/M	Stripping 2D Only (ACT)	ND	--	--	--	--	--	15.8	--	--
11	X-13	O/S-1	Hose Disconnect	ND	0.4	0.1	--	0.1	--	ND	--	--
11	MC-14 +	C/M	Tank Cleaning (Wash & Vent)	--	34.0	29.2	--	--	--	--	--	--
11	62039 +	C/M	Tank Cleaning (Wash & Vent)	--	36.0	29.8	--	--	--	--	--	--
11	X-12 +	A/B-5	Tank Cleaning (Wash & Vent)	--	191.2	ND	--	--	--	--	--	--
11	62038 +	A/B-5	Tank Cleaning (Wash & Vent)	--	133.0	6.9	--	--	--	--	--	--
11	DM-15	Bosun	Tank Cleaning (Wash & Vent)	--	49.8	0.3	ND	--	--	ND	--	--
11	DM-16	O/S-2	Tank Cleaning (Wash & Vent)	--	113.8	ND	ND	--	--	ND	--	--
11	08-P8	AREA	SwRI Personnel Room (During Tank Cleaning)	--	4.5	9.9	ND	--	--	ND	--	--
11	SB-2	Pumpman	Tank Cleaning (Wash & Vent)	--	181.7	14.7	ND	--	--	ND	--	--
11	64423	SwRI-1	Tank Cleaning (Wash & Vent)	--	104.3	ND	ND	--	--	ND	--	--
11	62037	SwRI-2	Tank Cleaning (Ventilation)	--	79.3	13.4	--	--	--	--	--	--
11	DM-19	O/S-2	Tank Cleaning (Wash & Vent)	--	69.0	ND	0.7	--	--	ND	--	--
11	DM-11	Bosun	Tank Cleaning (Wash & Vent)	--	138.3	68.5	ND	--	--	ND	--	--
11	X-15	A/B-5	Tank Cleaning (Ventilation)	--	--	--	ND	4.5	--	--	--	--
11	L-7	Pumpman	Open Gauging (Ballast (NCT)) (During Ventilation)	ND	21.0	18.2	ND	0.5	--	ND	--	--
11	DM-14	O/S-2	Tank Cleaning (Wash & Vent)	--	10.2	ND	ND	--	--	ND	--	--
11	64425	SwRI-1	Tank Cleaning (Wash & Vent)	ND	--	--	--	ND	--	--	--	--
12	X-16	Bosun	Tank Entry 7P	--	--	1479	--	--	--	--	--	--
12	DM-20	Bosun	Tank Entry 5A	--	65.5	--	--	--	--	--	--	--
12	68996	SwRI-1	Tank Entry 5A	--	58.0	--	--	--	--	--	--	--
12	X-23	Bosun	Tank Entry 5B	--	890.5	--	--	--	--	--	--	--
12	DM-12	Bosun	Tank Entry 7S	--	--	>11890	--	--	--	--	--	--
13	X-27 +	C/M	Tank Entry 3P,3S,5A,7P,7S	--	172.8	615.9	--	--	--	81.0	--	--
13	62035 +	C/M	Tank Entry 3P,3S,5A,7P,7S	--	115.8	669.5	--	--	--	95.0	--	--
13	DM-30	SwRI-1	Tank Entry 7P	--	--	839.7	--	--	--	--	--	--
13	SB-8	AREA	SwRI Personnel Room	ND	ND	0.2	ND	ND	--	ND	--	--

ND = Not Detected
+ = Parallel active and passive sample

TABLE VI. CALCULATED AMBIENT

Voyage Day	Sample No.		Worker	Activity	ACT	TCE	DCM	TCL	TTE	EDC	STY	NSS	EGL
13	DM-26	+	A/B-2	Tank Entry 1A	--	1718	--	--	--	--	--	--	--
13	62034		A/B-2	Tank Entry 1A	--	1893	--	ND	--	--	--	--	--
13	X-26	+	A/B-3	Tank Entry 1D	--	--	--	752.2	--	--	--	--	--
13	62033		A/B-3	Tank Entry 1D	--	--	--	908.4	--	--	--	--	--
13	X-18		A/B-5	Tank Cleaning (Washing 1B)	--	0.2	--	ND	--	10.1	--	--	--
13	X-25		AREA	SwRI Personnel Room	ND	--	--	--	0.3	--	--	ND	--
14	X-35	+	C/M	Tank Entry 1B,2D,3A,5B	ND	48.5	--	--	146.8	301.6	--	--	--
14	62032		C/M	Tank Entry 1B,2D,3A,5B	ND	201.4	--	--	221.8	539.6	--	--	--
14	X-21		SwRI-2	Tank Entry 1B,2D,3A,5B	ND	39.1	--	--	138.2	300.2	--	--	--
14	X-8	+	C/M	Tank Entry 1B,3A	--	--	--	--	194.3	83.4	--	--	--
14	63839		C/M	Tank Entry 1B,3A	--	--	--	--	236.7	75.2	--	--	--
14	X-40	+	SwRI-2	Tank Entry 1B,3A	--	--	--	--	63.3	65.4	--	--	--
14	63837		SwRI-2	Tank Entry 1B,3A	--	--	--	--	242.4	83.9		--	--
14	DM-41	+	A/B-3	Tank Entry 1D	--	--	--	--	267.4	144.2	--	--	--
14	62790		A/B-3	Tank Entry 1D	--	--	--	--	425.7	183.1	--	--	--
14	DM-47	+	A/B-2	Tank Entry 1A	--	--	--	--	256.0	140.2	--	--	--
14	62797		A/B-2	Tank Entry 1A	--	--	--	--	288.4	149.0	--	--	--
15	DM-40		Marine Chemist	Tank Entry 1A,1B,1D,2D,3A, 3P,3S,5A,5D	ND	9.1	--	5.7	5.3	9.2	0.7	--	--

ND = Not Detected
\+ = Parallel active and passive sample

The loading of the nine chemicals identified in the sampling plan was accomplished in the above manner. These nine chemicals were loaded into fourteen tanks. A retabulation of the distribution of these chemicals from a previous table is shown in Table VII. Also included is additional information regarding the quantity of cargo loaded per tank and the loading termination method.

TABLE VII. TANK LOADING INFORMATION FOR SELECTED CHEMICALS

Tank	Chemical	% of Tank Loaded	Shore Stop Tanks
1A	TCE	87.7	-
1B	EDC	42.5	x
1D	TCL	72.4	x
2A	EGL	98.3	-
2D	ACT	98.2	-
3A	TTE	51.3	-
3C	EGL	95.8	x
3P	STY	97.6	-
3S	STY	97.2	-
5A	TCE	98.2	-
5B	TCE	97.5	-
6S	EGL	55.4	x
7P	DCM	58.5	x
7S	DCM	52.5	x

The activities of five different crew members were documented at various times, and their exposures were monitored during the loading sequence Area samples were also collected. Three of the individuals were from the ship's crew which included the 2/M, 3/M-1, and 3/M-2. The other two were PRO's (PRO-1 and PRO-2. Restricted periodic gauging and restricted tank top-off were the major activities observed. A total of six tank top-offs were documented, five of which were conducted by the PRO's. Most of the periodic gauging was performed by the ship's officers. Discussion of these activities and the corresponding occupational exposures follows.

The last observation period (0000-0400 hours), before the discharge of all tanks was finished, consisted of more tank stripping and one periodic gauging round. The personnel involved in these activities were again the C/M and 3/M-2. The C/M did not appear out on the deck until the tanks were ready to be stripped. The 3/M, though, was out most of this last 4-hour period. The 3/M was made only one gauging round during this time. The tanks that he gauged were 2D, 2E, 3A, 3D and 4A. During the remaining time he was either in the deck house or on deck supervising the A/Bs who were disconnecting the hoses on the tanks that had

During the last hour of this period, the C/M stripped three more cargo tanks. These were 2D, 2E and 3A. This time the 3/M did not assist the C/M. Instead, the C/M performed the activity by himself. In the stripping of 2D and 2E, he viewed the liquid level of these tanks through the open tank hatch. He also observed the discharge pressure gauge. As before, he would continually go through a sequence of valve closings until all the product was discharged. In the stripping of 3A, he monitored the last stages of discharge through the tank gauging standpipe. He did not open the 3A expansion trunk.

Both the C/M and 3/M-2 were monitored for occupational exposure to chemical vapors during these activities. An area sample was also taken in the vicinity of the 2D cargo pump which had leaked a small amount of acetone during the stripping operation. The measured concentrations are shown below.

Sample No.	Time Period	Personnel	ACT	TTE	STY
X-19	0020-0355	3/M-2	ND	0.2	ND
X-100 +	0250-0355	C/M	ND	ND	7.1
64422* +	0304-0325	C/M	ND	--	15.8
64421	0258-0347	AREA	ND	--	15.6

+ Parallel samples

* Passive sample worn during tank stripping of 2D tank only.

tanks. The PRO-3, who came on duty at 1600 hours, was assigned to 4A and 4B. 3/M-2 assisted the C/M with the aft tanks. All tanks were gauged twice over the 2 hours.

During the middle of this 4-hour period, three cargo tanks were also stripped. These were 5A, 5B and 7P. The personnel involved in this task were the C/M and 3/M-2. In order to strip 7P, the C/M had to view into the tank through the open expansion trunk. As the cargo level dropped, the C/M signaled to 3/M-2 to close down on the cargo valve. They continued this procedure until most of the product was off-loaded. The stripping of 5A and 5B did not require opening of their expansion trunks. Instead, the C/M used the drop in the pump discharge pressure gauge as the indicator for throttling the cargo valve. Again, the 3/M-2 handled the closing of the tanks cargo valves. The duration of tank stripping lasted for approximately 15 minutes for each tank.

Between 2200 and 2400 hours, 6P, 6S and 7S were stripped. The same procedure used by the C/M to strip 7P was also utilized on these tanks.

Along with the occupational exposures measured on the above four individuals during the 4-hour period, one area sample was also collected to evaluate the contribution of styrene vapors from the ventilation of 3P and 3S. Its' location was about 20 feet forward of the 3S deckplate and downwind of it. The concentrations measured on these samples are shown below.

Sample No.	Time Period	Personnel	Concentrations, ppm ACT	TCE	DCM	TCL	TTE	EDC	STY
DM-5	1958-2200	3/M-1	ND	0.2	--	0.4	0.1	1.9	5.8
DM-17	2205-2351	3/M-1	ND	--	--	--	--	--	3.1
X-5	2045-2400	3/M-2	--	--	ND	--	--	--	2.4
DM-1	2016-2226	C/M	ND	ND	26.1	--	--	--	2.4
DM-13	2234-2358	C/M	ND	0.4	0.4	--	--	--	ND
62746	2025-2221	PRO-3	ND	--	--	--	--	--	8.1
64426	2224-2341	PRO-3	ND	--	--	--	--	--	0.7
62040	2154-2353	AREA	ND	--	--	--	--	--	50.1

Sample No	Time Period	ACT	TCE	DCM	TCL	TTE	EDC	STY
		Concentration, ppm						
DM-6	1028-1150	ND	9.9	2.8	ND	0.2	0.2	ND
DM-2	1028-1150	ND	ND	ND	ND	ND	ND	ND
X-6	1030-1110	--	0.4	1.7	--	--	ND	--
X-9	1130-1329	--	--	--	ND	--	0.1	--

During product discharge, both periodic gauging and tank stripping were monitored. Both 3/Ms, the C/M and one PRO were involved in periodic gauging. The task of tank stripping, however, was again handled primarily by the C/M with assistance from 3/M-2. Documentation on these activities occurred between 1500 hours of voyage Day 10 and 0400 hours of Day 11.

The initial observation was conducted on 3/M-2 between 1500-1629 hours. The only tank he gauged during this time was 4A. He spent most of his time near the loading manifold handling the initiation of discharge. He also tightened bolts on some of the valve flange connections which had developed leaks. The EDC flange (1B) and the flange connection on the runaround that was used to transport styrene washing slops to one of the deck tanks had developed leaks. 3/M-2's exposure was monitored on sample DM-9.

Sample No	Time Period	ACT	TCE	DCM	TCL	TTE	EDC	STY
		Concentration, ppm						
DM-9	1500-1629	ND	0.1	26.1	ND	ND	0.2	ND

The next observations were conducted from 2000-2400 hours. The start of this time period coincided with the commencement of tank ventilation of 3P and 3S. Between 2000-2200, periodic gauging duties were divided up between 3/M-1 and the C/M. 3/M-1 took care of the tanks forward of the Number 3 tanks while the C/M handled the tanks aft of the Number 3

- The ship's winch was connected to the hose by a strap.

- The hose flange was manuevered to the ship's flange and was bolted in place.

- The bolts were tightened and the strap removed.

A/B-1 and A/B-2 hooked up the hoses on the bottom level of the manifold while A/B-4 worked on the upper level hose connections. Hose connect times ranged from 2-5 minutes with an average of 4 minutes. There was no noticeable spillage of liquid during the entire activity.

The exposures for the above individual were monitored during the hose connect activity. Shown below are the individuals, the hoses they connected or the flanges they removed, and their exposure sample numbers.

Sample No.	Personnel	Hoses Connected	Ship's Flanges Removed
DM-6	A/B-1	2A, 2D, 3A 5A, 5B, 6P, 7P	--
DM-2	A/B-2	2A, 2D, 3A 5A, 5B, 6P, 7P	--
X-6	A/B-3	--	1A, 1B, 2A, 3F, 4A, 4C, 5B, 7P
X-9	A/B-4	1B, 1D, 3C, 3D, 4A, 4C	--

The sample times and concentration of chemical vapors collected on these samples are shown below.

Discharge to Terminal No. 3

The bulk of the ship's cargo was off-loaded at this terminal. In addition, the two styrene tanks, 3P and 3S, were washed and ventilated while the ship was docked at Terminal 3.

Prior to hose connect, the 2/M took initial ullage and temperature readings on the remaining tanks. The 2/M was accompanied by two dock employees who also made similar measurements. The readings were taken through the gauging standpipes. Although all tanks were gauged, the 2/M's exposure to chemical vapors were monitored only for the chemicals contained in the No. 1 through the No. 3 tanks. When he reached the first No. 4 tank he requested that the sampler be removed. The chemical concentrations measured on the sample are shown below.

Sample No.	Time Period	Concentration, ppm ACT	TCE	TCL	TTE	EDC	STY
X-2	0839-0900 1010-1121	ND	0.3	0.3	0.2	0.1	ND

Hose hook-up was a more complex activity at this terminal than at the previous terminals A total of four crewman were involved. Prior to connecting the hoses to the ship's valves, the valve flanges were unloosened and removed. This task was performed by A/B-3. He removed eight flanges spending approximately two minutes per flange. The other three crewmen connected the dock hoses to the ship's valves. Their procedure was as follows:

- o The hose was moved to the vicinity of the ship's manifold by a dock winch.
- o The crewmen proceeded to remove the blind flange from the hose.

Tank 3P was stripped of cargo in much the same fashion as 3S. However, the duration and frequency of sighting into 3P were slightly different. The C/M viewed 3P only seven times through the Butterworth opening for the following duration: 6, 7, 12, 15, 43, 58 and 60 seconds. The vapor exposures during stripping are summarized below.

Sample No.	Time Period	Personnel	STY (ppm)
DM-4	0746-0802	C/M	5.7
DM-3	0814-0833	C/M	ND

Disconnect of the 3S and 3P loading hoses followed after discharge was completed. Only one crewman, A/B-1, performed the disconnect on these hoses. His attire consisted of shorts, an open short sleeve shirt and rubber gloves. These were the same clothes he wore when he was involved in hook up of hoses prior to barge loading. His lack of clothing was much more noticeable during this hose disconnect activity because when he loosened the bolts to each hose about two gallons of styrene splashed down into the drip pan and partially onto his legs. Once all bolts were removed, the dock crane lifted the hose from the last bolt. At this time more liquid styrene spilled out into the drip pan. Finally, A/B-1 bolted the blind to the hose and motioned the dock crew to remove the hose. The total time for the activity was 11 minutes. A/B-1 was monitored for exposure to styrene vapor during this activity. The measured concentration is shown below on Sample DM-8.

Sample No.	Time Period	STY (ppm)
DM-8	0841-0852	12.9

Sample No.	Time Period	Personnel	STY (ppm)
X-3	1553-1603	A/B-4	ND
CG2-020	1600-1604	A/B-3	ND
62745	1556-1605	AREA	9.8

Discharge to Terminal No. 2

As a result of rainy weather conditions, documentation and occupational exposure monitoring of the hose hook up activity was not conducted at Terminal 2. Exposure monitoring was performed on crewmen involved in periodic discharge gauging after the weather cleared. Documentation and monitoring of the 3P and 3S tank stripping activity and hose disconnect was also accomplished.

Occupational exposure samples were collected during a portion of the periodic tank gauging activities. The personnel monitored for periodic tank gauging were 3/M-1 and PRO-3. Shown below are the exposure concentrations measured on these samples.

Sample No.	Time Period	Personnel	STY (ppm)
DM-7	2042-2345	3/M-1	ND
62743	2104-2304	PRO-3	0.9

The first tank to be stripped was 3S. Toward the end of discharge of 3S, the C/M instructed one of the A/Bs on watch to remove the Butterworth (BW) plate. During the next 15 minutes, the C/M peered into the 3S tank through the BW opening to make sure that the maximum amount of liquid was pumped out of the tank. During this time, he made 14 consecutive sightings through the opening ranging from 4-17 seconds each. His breathing zone was roughly four to five feet above the opening. Each time he would look into the tank, he motioned to one of the A/Bs to close down slightly on the product valve.

Sample No.	Time Period	Personnel	STY (ppm)
X-4	1049-1123	A/B-1	ND
02-P12	1050-1107	A/B-2	ND
CG2-015	1112-1123	A/B-2	ND
63778	1049-1104	AREA	4.5

During the off-loading of styrene to the barge, the 2/M and Pumpman performed periodic tank gauging on 3P and 3S. Although the Pumpman was out on deck a similar amount of time as the 2/M, he did not become involved in tank gauging until the end of discharge. The Second Mate made ullage readings over a 3-hour period. He gauged tank 3P five times and 3S three times for durations ranging from 15 to 30 seconds. During the last hour, the Pumpman gauged the tanks. He made two rounds on each tank spending less than 31 seconds during each visit. He finally stationed himself near 3S until discharge was completed. Both crewman usually stood with their breathing zone approximately 2-3 feet above the standpipe. Both crew members were monitored for styrene exposure during these activities. However, no styrene was detected on the samples taken, as shown below.

Sample No.	Time Period	Personnel	STY (ppm)
SB-25	1310-1611	2/M	ND
X-7	1504-1559	Pumpman	ND

After discharge had stopped, the hoses were removed by two other crewmen, A/B-3 and A/B-4. A/B-3 unbolted the cargo hose flanges. When the first bolt was loosened, a cupful of product drained from the connection. During this time, A/B-4 was stationed above the manifold and eventually operated the winch to transfer the hoses back to the barge. The total time for this activity was 3-4 minutes. In addition to monitoring both individuals, an area sample was also collected near the 3P and 3S manifold valves. The measured concentrations are shown below.

VII.2 Product Discharge

Cargo was off loaded from the ship at four terminals and one barge. Detailed observation of the discharge to the first and last terminal was not performed because the off-loaded cargo (Lignin Liquor) was not one of the chemicals selected for the sampling program. Documentation of the activities of the crew was accomplished at the other three locations. The first of these three was the discharge of half of the styrene cargo to a barge. The final half of this cargo was off-loaded at the second terminal. Finally, the bulk of the ship's cargo was discharged at the third terminal.

The activities of ten different crewmen and PRO were documented and monitored during these cargo discharge operations. The ten crewmen consisted of four A/Bs, one O/S, the C/M, the 2/M, both 3/Ms and the Pumpman. The predominant activities performed by the unlicensed crew were cargo hose hookup and disconnect. Periodic tank gauging was handled by the Mates and Pumpman. Tank stripping was conducted primarily by the C/M. The observations and monitored exposures are summarized below.

Discharge to a Barge

As the barge came alongside the ship, A/B-1 and A/B-2 removed the bolts from the flanges of the 3P and 3S manifold valves. Liquid spillage was not observed when the flanges were unloosened. Following this, A/B-2 moved forward to help secure the barge to the ship. Upon his return, he and AB 1 proceeded to secure the barge loading hose to the 3P and 3S manifold valve flanges. Flange removal and hose hookup took two and four minutes, respectively.

Exposures were measured on both of the A/Bs during hose hookup. A/B-1 was monitored with one continuous sample while two sequential samples were collected on A/B-2: one for flange removal and one for hook up of the barge hose. In addition to the personal samples, one area sample was taken with a passive badge in between the 3P and 3S valve flanges during flange removal. These concentrations are shown below.

The PRO's position relative to the gauging standpipe for the top-off of 3S and 3P was similar to 5A. During these gaugings though he constantly kept his head above the standpipe viewing the gauging tape repeatedly. He observed the tape continuously for 4-1/2 minutes on 5A followed by a 2-minute reading on 3S. The total time spent near the 3S gauging standpipe was 13 minutes. He spent about a fourth of this time actually topping off 3P. The actual gauging on 3P lasted for 3-minutes during which time, he left the tape in the gauge pipe and looked at it continuously.

After the loading of 3P and 3S, nitrogen was blown through the cargo piping from shore to drain the lines into the ship tanks. When 3P was purged, styrene spilled out of the gauging standpipe. After noticing the leak, the PRO secured the ullage cap, and the leak stopped. The period of time he spent in the vicinity of the styrene vapors from this spill was about 2 minutes.

Three separate occupational exposure samples were collected on the PRO-2, one for each top-off. In addition, a parallel (passive and active) area sample was taken during top-off of 3S. Its' location was 2 feet above and 6 inches to the stern of the 3S standpipe. The concentrations on these samples are shown below.

Sample No.	Tank No.	Type of Sample	Concentration (ppm) TCE	Concentration (ppm) STY
SB-36	5A	P	58.4	---
03-P19	3S	P	--	7.5
H-9 }+	3S	A	--	ND
62799 }+	3S	A	--	15
SB-38	3P	P	--	6.6

+ Parallel Sample

During the first hour of the last observation period, PRO 1 made three soundings of tank 1A each about 20 minutes apart. In the last hour, he stationed himself about 20-30 feet away from the tank hatch. During this hour, he also gauged the tank three times. About 10 minutes before loading had stopped, his position was next to the standpipe where he continually checked the product level until loading of 1A was finished.

Occupational exposures were monitored during each of the periods. Area samples were also obtained during the top-off of tanks 5B and 1A. The following concentrations were measured.

Sample No.	Tank No.	Type of Sample	Concentration (ppm) TCE	STY
TX-104	3P & 3S	P	---	ND
MC-13	5B	P	56.9	---
H-11	5B	A	>154.5	---
MC-11	1A	P	28.8	---
MC-18	1A	A	>123.0	---

Activities of PRO-2 (0016-0037), (0215-0243), (0245-0259) Day 2

This PRO stood the 0000-0800 watch. During his watch, he topped off three tanks, 5A, 3S and 3P. The periods shown above correspond to the times during which he was being monitored for each tank top-off, respectively.

The overall time PRO-2 spent topping-off the 5A tank was approximately 8 minutes. He made six ullage readings during this time; five of these readings took from 6-23 seconds, and one reading took 2-minutes. He was located downwind of the standpipe with his breathing zone approximately 1-2 ft above it for each gauging. The standpipe was approximately 20 feet downwind from the expansion trunk where the tank was being vented.

Later in his watch, his area of responsibility shifted to three aft tanks and one forward tank (1B). Two of the aft tanks, 7S and 7P, were gauged twice each within one hour. The other aft tank, 5B, was gauged once as it had resumed loading during this time. He made one ullage reading at 1B. Not long after this reading was made, loading was stopped on 1B. The method and duration of these tank gaugings were the same as noted previously.

The 3/M's exposure during the entire observation period was monitored on the sample shown below:

Sample	DCM	TTE	EDC	STY
SB-16	0.3	0.13	ND	ND

Activities of PRO 1 (2116-2328) Day 1, (1757-1841) and (2152-0006) Day 2

The PRO performed periodic gauging of 3P and 3S, top-off of 5B, and periodic gauging and top-off of 1A during time period 1, 2 and 3, respectively.

Exact observation of PRO 1 during periodic gauging of 3S and 3P was not possible because the activities of other ship personnel were being documented. However, based on discussions with the PRO he gauged these tanks once every 20 minutes between 2116-2328 hours.

During the second time PRO-1 topped off tank 5B. The total time spent near 5B was approximately 15 minutes. During this time, he gauged the tank nine times. When not actually taking an ullage reading, he sat about two feet downwind of the standpipe on cargo piping. This location was also downwind of the vapors venting from the 5B tank hatch.

tanks 3A, 5A, 3C and 1B. He made three soundings at 3A and 1B and one sounding at 5A and 3C. He also gauged other tanks that were already being loaded. These were 5B, 2D, 4C, 7P and 7S. He made one sounding at each of these except for 4C and 2D, of which he gauged twice.

The top-off of 2D was performed over a 22-minute period. During this time he gauged the tank 11 times. The gauging durations ranged from 15-30 seconds each. The odor of acetone vapors was very evident around the gauging standpipe. These vapors were from the 2D tank hatch which was upwind of the standpipe. The acetone tank was one of the chemical tanks that was not short loaded.

One occupational exposure sample was collected during each of these periods. The concentration of the chemicals monitored are shown below.

Sample No.	Time Period	Day	Concentration, ppm ACT	TCE	DCM	TTE	EDC	STY
MC-17	1727-2114	1	ND	ND	ND	ND	ND	ND
MC-19	2118-2154	1	176.7	---	---	ND	---	ND

Activities of 3M-2 (0005-0346) Day 2

3/M-2 performed periodic tank gauging during this watch period. He made two gauging rounds to four of the tanks located on the forward half of the ship within the first 30 minutes of the period. These tanks were 3P, 3S, 3A and 1B. With the exception of one 9-minute gauging period at 3A, 3/M-2 spent between 10-50 seconds making the actual ullage reading on the other tanks during these two rounds. His breathing zone was upwind and normally 1-2 feet above the standpipe.

Activities of 2/M (1524-1701) and (1840-2109) Day 1

The second mate performed restricted periodic tank gauging during both observation periods. During most of the first period, styrene (3P & 3S) was the only chemical being loaded. Toward the end of this period, loading of 2D (ACT), 7P (DCM), and 7S (DCM) had commenced. The 2/M gauged each of these tanks once during this period. Although more tanks were being loaded during the second period, the 2/M gauged only two tanks. One of the tanks was 5B (TCE). A heel was being loaded into 5B. The 2/M stayed near the 5B standpipe continuously for 11 minutes gauging the tank every 30 seconds. The other tank that he gauged was 2D, which now had resumed loading. He gauged 2D three times for a period of 2 minutes each and one time for 30 seconds.

With the exception of 7P & 7S, all gauging standpipes were downwind of their respective tank hatches. In addition, styrene was being vented by vapor return.

One occupational exposure sample was collected on the 2/M during each of these observation periods. The concentration of the chemicals monitored are shown below.

Sample No.	Time Period	Day	Concentration, ppm ACT	TCE	DCM	STY
H-8	1524-1701	1	---	---	0.2	ND
03-P18	1840-2109	1	7.7	ND	---	ND

Activities of 3/M-1 (1727-2114) and (2118-2154) Day 1

This 3/M was involved in periodic tank gauging during the first period and tank top-off of 2D during the second period. Between 1727-2114 hours, 3/M-1 made initial gaugings of the heel loading of four different

The final activity observed at Terminal 3 was the disconnect of loading hoses by two unlicensed crewmen, A/B-3 and O/S-1. The entire activity lasted for approximately three hours. Basically, A/B-3 performed most of the hose disconnects. O/S-1 assisted the A/B for the first hour; however, most of O/S-1's time was spent bringing equipment from the dock to the ship. A/B-3 disconnected the hoses in the reverse order described earlier for hose connect. When the flanges were unbolted some residual liquid would spill out. The amount was usually small because after loading each cargo line was back purged with N_2 from the shore. The hoses that A/B-3 disconnected were 3C, 3D, 7P, 3A, 5B, and 6P. The other cargo lines had been removed earlier the day before. The occupational exposures of these two individuals were monitored while they performed the above activities. The concentrations measured are shown below.

Sample No.	Time Period	Personnel	ACT	TCE	DCM	TTE	STY
X-13	0444-0741	O/S-1	ND	0.4	0.1	0.1	ND
X-14	0453-0745	A/B-3	ND	0.4	1.4	0.3	ND

VII.3 Ballasting

Periodic gauging of the ship's ballast tanks by the Pumpman was documented twice, once at the end of loading while the ship was in port and again during tank cleaning on the ballast leg of the voyage. The condition of the ballast tanks were different on each occasion. The first time the tanks were ballasted they were "dirty" because they contained residual naptha product which had been previously carried, off-loaded, and once ballasted prior to reaching the loading port. Consequently, there existed a potential for exposure to naptha vapors for the Pumpman. Prior to the second ballasting operation, the ballast tanks were cleaned and ventilated. As a result, exposure to naptha vapors was anticipated to be low as compared to the first ballasting operation.

The method used to periodically gauge the ballast tanks was the open gauging method. As noted in Section I, the ballast tanks contained no other means of venting except through the ullage ports atop the tank hatches. Restricted gauging standpipes were not available on these tanks. Consequently, ullage readings had to be taken through the open ullage port, which also served as the vent.

Documentation of the Pumpman's work practices during gauging, as well as monitoring his exposure, was performed during the first ballasting activity. However, because tank cleaning was the major activity when the second ballasting operation was performed, only exposure monitoring was accomplished at that time. The tanks that were ballasted at the loading port were the 2P and 2S tanks. The Pumpman made six visits to 2S and four visits to 2P. Except for two ullage readings, that lasted 1-2 minutes, all gauging durations lasted for less than 60 seconds. Initially, he would visually sight through the ullage port, to make sure his gauging tape float was touching the liquid surface. Since it was during the day, he used a mirror to reflect light into the tank so that he could see inside. After the fourth gauging, he changed his technique to viewing the gauging tape on the edge of the ullage port from an upwind position. He could not view directly into the tank because the naptha vapors were too strong.

One occupational exposure sample was collected for each ballasting operation. During the second ballasting other chemicals venting from tanks being cleaned were also noted. The exposure concentrations that were obtained on these samples are shown below. The samples are listed in the order that they were taken.

Sample No.	Chemical Concentration, ppm ACT	TTE	NSS
SB-98	--	--	111.8
X-25	ND	0.3	ND

VII.4 Tank Cleaning

Extensive tank cleaning was performed on both the laden and ballast portions of the voyage. The purpose for cleaning the tanks was to gasfree the ship because it was going into dry dock at the end of the voyage. During the laden voyage the ship's six ballast tanks were washed and ventilated over a two day period. On the ballast leg, the cargo tanks were cleaned. Some of the cargo tanks required both washing and ventilation while others were just ventilated. As many as nine different crew members were monitored for occupational exposure during both cleaning operations. In some cases, as many as six individuals were being monitored at one time. Consequently, a general description of these activities will be given along with the monitored exposures.

Cleaning of Ballast Tanks

During the first day of the laden voyage, all six of ballast tanks were water washed. Washing was not initiated until the ship was far enough away from shore (50 miles) to discharge the dirty wash water overboard. The two individuals who supervised this activity were the C/M and the Bosun. Although they were being assisted by A/Bs and O/Ss, only the activities of the C/M and Bosun were monitored and documented during washing. While the exact timing and sequence of the washing procedure varied from tank to tank, in general, the following method was used.

- The hatch on the tank to be washed was opened for visual determination of wash water level.
- Wash water was pumped in using a portable Butterworth machine.
- The ballast pump was started and the discharge valve was adjusted to balance inflow to outflow.

- To set the flow, periodic sighting was made into the tank hatch to observe the water level.

- When the rate was balanced, the person washing the tank would station himself near the manifold railing where the slops were being discharged overboard.

- Clearness of the wash water was the sign of a clean tank.

- After all ballast tanks on one side of the ship were finished, the ballast deck piping was drained onto the deck.

The starboard ballast tanks were washed first. The Bosun handled 2S while the C/M took 4S. After finishing 4S, the C/M worked 5S. The Bosun assisted him for a short while, then directed the unlicensed crew to move the washing machines from 2S and 4S over to the port tanks. Once the starboard ballast lines were drained the C/M and Bosun, commenced working of the port ballast tanks in the same manner. While on the port side, the C/M spent most of his time just forward of the 4P expansion trunk controlling the washing rate. The Bosun accompanied the C/M. The Bosun also directed the A/Bs and O/Ss to set stripping lines into the starboard tanks to strip out the residual wash water in these tanks.

During the tank washing activity, the C/M and Bosun were monitored for occupational exposure to naptha vapors. Two consecutive samples were obtained on each of these individuals. The first set monitored their exposure while washing the starboard ballast tank. The second set was worn while these individuals worked with the port tanks. Listed below are the measured concentrations.

Sample No.	Personnel	Time Period	Naphtha (ppm)
MC-12	C/M	1237-1412	49.9
CG2-018	Bosun	1209-1426	36.9
MC-20	C/M	1420-1524	38.5
SB-18	Bosun	1429-1519	35.8

On the next day, all six ballast tanks were ventilated using the ship's central Kathabar blower. Air supplied by this unit is sent to the ship's manifold where it can be transferred to any tank on the ship by means of a flexible hose connection. At this time the hoses were connected to the port and starboard ballast tank manifold valves. The air was then discharged into the tank through the cargo drop at the tank bottom. The tank vapors were discharged to the atmosphere through the tanks' ullage ports and their Butterworth openings.

The activities of three of the crewmen were documented during the morning while the ballast tanks were being ventilated. These were the Bosun, O/S-1 and O/S-2. The two O/Ss moved Butterworth hoses near the 6A and 6B tanks so that these tanks could be washed immediately after their cargo was off-loaded at the first discharge terminal. The Bosun directed these two individuals to make ready other equipment and to secure items that were not going to be used. Periodically, the Bosun viewed into some of the ballast tanks to see how dry they were. Similar activities such as securing equipment on deck, were performed after lunch. The workers this time were O/S-1 and O/S-3.

In addition to monitoring the exposures of these individuals during their morning and afternoon work activities, one of the SwRI personnel also wore a passive dosimeter during the afternoon activities. These exposures are noted below.

Sample No.	Personnel	Time Period	Naphtha (ppm)
X-1	O/S-1	0930-1142	23
CG2-019	Bosun	0849-1112	>89.8
02-P20	O/S-2	1035-1132	18.0
X-10	O/S-1	1326-1456	7.8
02-P17	SwRI-1	1336-1450	3.7
CG2-017	O/S-3	1323-1413	14

Cleaning of the Cargo Tanks

The cleaning of the ship's cargo tanks commenced the day the ship left Terminal No. 3. At this time, only one tank contained cargo, and it was subsequently off loaded at the fourth and last terminal. The majority of the cargo tanks were washed with water and gas freed. Eight of the tanks, however, were only ventilated. These eight tanks contained one of the chemicals selected for exposure monitoring. These were 1A, 1D, 5A, 5B, 2D, 3A, 7P, and 7S. Tank 1B was the only selected chemical tank that was washed prior to being ventilated. Both Coppus blowers and the Katharbar system were used to ventilate the tanks.

Five different crewman were documented and monitored during the tank cleaning operation. These included the C/M, Bosun, Pumpman, A/B-5, and O/S-2. These individuals performed a variety of tasks. The C/M performed the actual washing of tank 1B. He was assisted by the Bosun, who washed 6P and 6S. The Bosun also supervised the unlicensed crewmen in preparing and moving equipment to the various tanks being washed. After a tank washing was finished, the Bosun removed the drain plugs to drain the cargo deck piping. The Pumpman also removed drain plugs on cargo lines while he was on deck. In addition, the Pumpman transferred ballast between the forward ballast tanks to adjust the ship's list and facilitate maximum removal of wash water. During washing O/S-2 and A/B-5 moved the Butterworth machines from tank to tank and removed blind flanges on all vent lines at the B/3 mast risers.

All of these tasks were performed while most of the tanks of interest were being ventilated. The odor of chemical vapors was prevalent over the entire ship's deck. The vapors of TCE and DCM were most predominant because of the cargos high volatility and because these products had been carried in more than one tank.

Occupational exposure to the chemical vapors was monitored on each of the five ship's crewmen involved in the tank cleaning activities. Parallel passive and active samples were obtained on the C/M and A/B-5. SwRI personnel also wore passive badges while they were on deck documenting the activities of the crew. The measured exposures on these samples are shown in the following table.

Sample No.	Personnel	Time Period	ACT	TCE	DCM	TCL	TTE	STY	NSS
			Concentration, ppm						
MC-14 +	C/M	1226-1500	--	34.0	29.2	--	--	--	--
62039 +	C/M	1226-1500	--	36.0	29.8	--	--	--	--
X-12 +	A/B-5	1245-1350	--	191.2	ND	--	--	--	--
62038 +	A/B-5	1245-1350	--	133.0	6.9	--	--	--	--
X-15	A/B-5	1412-1455	--	--	--	ND	4.5	--	--
DM-15	Bosun	1217-1323	--	49.8	0.3	ND	--	ND	--
DM-11	Bosun	1327-1452	--	138.3	68.5	ND	--	ND	--
SB-2	Pumpman	1258-1453	--	181.7	14.7	ND	--	ND	--
L-7	Pumpman	1545-1625	ND	21.0	18.2	ND	0.5	ND	ND
DM-16	O/S-2	1229-1335	--	113.8	ND	ND	--	ND	--
DM-19	O/S-2	1335-1502	--	69.0	ND	0.7	--	ND	--
DM-14	O/S-2	1535-1553	--	10.2	ND	ND	--	ND	--
64423	SwRI-1	1240-1427	--	104.3	ND	ND	--	ND	--
64425	SwRI-1	1551-1625	ND	--	--	--	ND	--	--
62037	SwRI-2	1302-1510	--	79.3	13.4	--	--	--	--

+ Parallel samples

The only tank of interest that was washed and gas freed, was 1B. This tank was washed by A/B-5. The washing was performed the day after the ship left the last discharge terminal. A/B-5 did not monitor the wash water level through the tank hatch. The hatch was kept closed. Instead, he stationed himself near the 1B tank pump and balanced wash water rates by opening and closing the pump discharge valves. This procedure was similar to that used to strip tanks of cargo. To determine if the tank was clean, he would open the cargo line drain valve, collect a sample of the wash water with his hands, and smell and taste the liquid for the presence of EDC. On the third test he could not detect EDC; therefore, he ceased washing of 1B.

A/B-5's exposure to EDC and to other chemical vapors being vented from nearby tanks was monitored in the following sample.

Sample No.	Time Period	TCE	TCL	EDC
X-18	1411-1434	0.2	ND	10.1

Tank Entry

All enclosed spaces, especially cargo tanks, had to be gas-freed for the ship to enter dry dock. It is very seldom that gas-freeing can be accomplished without tank entry by some of the ship's personnel. The tanks were entered to test the tanks to see if they were, in fact, gasfreed. Only after the tank concentration was measured could the C/M determine if more cleaning or ventilation was necessary. If tank conditions indicated that continued ventilation would not be sufficient to produce a gas free state, then tanks were entered to do manual hand mucking. Tanks were also entered to alleviate improper equipment malfunction or ship design that would have prolonged the gas-freeing time of certain tanks.

All in all, tanks were entered on 11 different occasions. The individuals that entered tanks included the Bosun, the C/M and three A/Bs (A/B-1, A/B-2, and A/B-3). The activities performed by these individuals were documented and their exposures were monitored. To compliment the exposure measurements, grab samples were collected in glass syringes and later analyzed on a gas chromotograph. The grab samples were collected by SwRI personnel who accompanied the crewmen into the tank when possible. On certain occasions the SwRI personnel also wore personal sampling equipment.

The first series of tank entries involved the Bosun, exclusively. He entered four tanks (7P, 7S, 5A, and 5B) for the purpose of eliminating conditions that would have extended the ventilation time for these tanks.

Two of these tanks, 7P and 7S, contained pump priming cans that were used for priming of the tank's cargo pump. After cargo was off-loaded, approximately 55 gallons of residual cargo remained in the reservoirs. Because the liquid surface was small and the priming cans were located in areas shielded from the ventilation air flow, removal by evaporation was slow. To accelerate the evaporation the Bosun entered these tanks to open the drain valves on the priming cans. This allowed the residual cargo to spread out over the tank bottom and evaporate more rapidly.

Accummulation of residual cargo in hard to ventilate areas of the tank was also the reason tanks 5A and 5B had to be entered. The areas in question were the pump sumps. Fixed stripping lines from the deck to the bottom of the sump had become clogged by previous cargo that had polymerized in these tubes. Consequently, to remove the liquid from the sump, stripper hoses had to be physically placed inside the sump at the tank bottom. The Bosun performed this activity in both 5A and 5B.

Precautionary procedures were minimal in all four entries. Before entering, oxygen, combustible gas and toxicity measurements were not taken. The Bosun utilized his sense of smell to tell him how strong the chemical vapors were inside the tank. Even though the vapor concentrations were high in some of these tanks, the rationale that he was only going to be down in the tanks for a short time was used to justify his entry. With the exception of 5A, the duration of the tank entries was approximately two minutes. His tank entry time on 5A was six minutes. An organic vapor cartridge respirator was worn only when tanks 5B and 7S were entered. A ship's crewman was on standby on deck during each of the Bosun's entries except for 5B.

Shown in Table VIII are the occupational exposure concentrations measured on the sample tubes the Bosun wore during each tank entry. Grab samples were also collected during each entry except for tank 7P. A parallel exposure sample was collected on an SwRI employee who who entered tank 5A with the Bosun.

At some point in the ventilation process, tanks were entered by the C/M to determine if they were gas-freed or if more cleaning or ventilation was required. The C/M was the only individual that performed the tank testing activity. In a two-day period, he made three series of multiple tank entries. During each series, the following items were documented. While the C/M was in the tank, he did not have anyone standing by on deck.

TABLE VIII. TANK ENTRY EXPOSURE CONCENTRATIONS ON THE BOSUN

Tank No.	Type of Sample	Sample No.	Duration (min)	TCE (ppm)	DCM (ppm)
5A	Personnel	DM-20	6	65.5	--
	Personnel*	68996	12	58.0	--
	Grab				
5B	Personnel	X-23	2	890.5	--
	Grab	--	--	2000	--
7P	Personnel	X-16	2	--	1479
7S	Personnel	DM-12	2	--	>11890
	Grab				5500

* SwRI Personnel No. 1

He did not wear any protective equipment during the entries. Prior to an entry, in-tank drop line measurements were not made. Instead, the C/M utilized an oxygen meter and a combustible gas meter to test the tank atmosphere as he descended into the tank. Once he was in the tank, toxicity level measurements were made with a Draeger tube system. The time spent in each tank was predicated on the time required to complete all three measurements. In some tanks, additional time was taken to visually inspect tank surfaces. The entry durations ranged between 2.5 to 8 minutes.

The first series of tank entries by the C/M were made into 1A, 1D, 3S, 3P, 5A, 7S and 7P. Based on Draeger tube measurements and visual tank inspection, 1A and 1D required manual hand mucking to facilitate gas-freeing. For the other tanks, only continued ventilation was necessary. On the morning of the second day the second series of tank entries were made into 1B, 2D, 3A, and 5B. Two of the four tanks (1B and 3A) contained a significant amount of rust, debris, and residual chemical in wash water. Ventilation was continued on these tanks as well as the other two. Later in the afternoon 1B and 3A were re-entered and tested again. Because only a small reduction in vapor concentration had been achieved, it was decided that hand mucking of 1B and 3A would also be required.

The C/M's exposure during tank entry for vapor testing was monitored on three sets of parallel passive and active dosimeters. Each set corresponded to each series of entries. The exposures are shown in Table IX, along with the entry duration (in brackets [ ]). Also shown in the table are exposures that were monitored on the SwRI personnel. SwRI personnel accompanied the C/M into 7S and 7P on the first series and every tank entry on the second and third series. In addition, the grab samples collected by the C/M with the Draeger tube, as well as the GC analysis of the syringe grab samples, are also shown in Table IX.

The entry durations for tank mucking were longer than the durations for the entries made by the C/M and the Bosun. These activities lasted between 15-22 minutes. The tasks performed during tank mucking required equipment such as a broom, dust pan, bucket, and a supply of dry rags. The individuals involved in this activity swept the tank floor clean of loose rust debris. Any moisture or puddles of liquid were sponged up with the dry rags and wrung out into the same buckets holding the solid debris. The predominant location where liquid had accumulated was in the pump sump. Once the bucket was filled it was pulled to the top by a crewman on deck and replaced with an empty one. The deck crewman emptied the buckets by

TABLE IX. OCCUPATIONAL EXPOSURES OF C/M DURING TANK ENTRY

			Exposure Concentration, ppm/[Entry Time, Minutes]										
Entry Round	Type of Sample	Sample Number	TCE 1A	EDC 1B	TCL 1D	ACT 2D	TTE 3A	STY 3S	STY 3P	TCE 5A	TCE 5B	DCM 7S	DCM 7P
1	Personnel	X-27 +	2	--	2	--	--	81.0 [4.2]	2 [6.03]	172.8 [3.1]	--	615.9 [5]	[4]
	Personnel	62035 +	2	--	2	--	--	95 [4.2]	[6.03]	115.8 [3.1]	--	669.5 [5]	[4]
	Personnel 1	DM-30	--	--	--	--	--	--	--	--	--	839.7 [5]	[5]
	Area (Draeger)	--	100	--	200	--	--	60	70	90	--	100	750
	Area (Grab) 3	--	140	--	657	--	--	115	35-52	172	--	47	1327
2	Personnel	X-35 +	--	301.6[4.35]	--	ND	146.8[2.72]	--	--	--	48.5[3.33]	--	--
	Personnel	62032 +	--	539.6[4.35]	--	ND	221.8[2.72]	--	--	--	201.4[3.33]	--	--
	Personnel 1	X-21	--	300.2[3.5]	--	ND	138.2[2.87]	--	--	--	39.1[3.37]	--	--
	Area (Draeger	--	--	5	--	0	100	--	--	--	0	--	--
	Area (Grab) 3	--	--	500	--	ND	150	--	--	--	60	--	--
3	Personnel	X-8 +	--	83.4[7.67]	--	--	194.3[4.18]	--	--	--	--	--	--
	Personnel	63839 +	--	75.2[7.67]	--	--	236.7[4.18]	--	--	--	--	--	--
	Personnel 1	X-40 +	--	65.4[6.18]	--	--	63.3[4.2]	--	--	--	--	--	--
	Personnel 1	63837 +	--	83.9[6.18]	--	--	242.4[4.2]	--	--	--	--	--	--
	Area (Draeger)	--	--	20-30	--	--	150	--	--	--	--	--	--
	Area (Grab) 3	--	--	170	--	--	214	--	--	--	--	--	--

+ Parallel active and passive samples

1 SwRI personnel

2 Samplers were not worn when C/M entered these tanks

3 Syringe vapor sample analyzed by gas chromatography on board ship

dumping their contents overboard. This procedure was repeated until all loose rust and liquid residue were removed from the tank. As previously mentioned, a total of four tanks were entered for tank mucking: 1A, 1B, 1D, and 3A. Tank 1A and 1D required only one individual each to clean these tanks because they were fairly small. Tank 3A and 1B, on the other hand, utilized a work compliment that included the two A/Bs that entered 1A and 1D as well as one other A/B and the Bosun.

The tank testing performed by the C/M was the only tank monitoring accomplished prior to man entry for tank mucking. Because the crew entered 3A and 1B within a half an hour after the C/M's entry to test these tanks, it was reasonable to expect these tanks still had the about same vapor concentration. On the other hand, entry into 1A and 1D was performed approximately four hours after these tanks were tested.

Protective equipment usage varied during these tank entries. Gloves were the only protective clothing worn for entry into 1A and 1D. The A/B who entered 1A wore cotton material gloves and the A/B who entered 1D wore rubber gloves. When these two crewmen entered 1B and 3A, they also wore an organic vapor cartridge type respirator. One of the two other crewmen comprising the four-man cleanup team of 1B and 3A also wore similar protective equipment. The fourth one, however, did not wear a respirator. The only consistent safety procedure during all these tank entries was the presence of on-deck personnel while people were in the tank. This situation was more of a necessity because someone was required on deck to empty the bucket of debris being generated. Tanks were not ventilated during entry.

Occupational exposures were monitored on the two A/Bs (A/B-2 and A/B-3) who were involved in all four tank entries. On every entry, each A/B wore a passive and active dosimeter. Both single and multiple grab samples were also collected during these tank entries by SwRI personnel in the vicinity where the A/Bs were working. The exposure concentrations and entry duration for these two individuals are shown in Table X.

TABLE X. OCCUPATIONAL EXPOSURE OF A/B-2 AND A/B-3 DURING TANK MUCKING

Tanks Entered	Crewmen	Sample No.	Exposure conc., ppm [entry time, min] TCE	TCL	TTE	EDC
1A	A/B-2	DM-26 +	1718[16]	--	--	--
		62034 +	1893[16]	--	--	--
		Grab	2150	--	--	--
1D	A/B-3	X-26 +	--	752.2[15.83]	--	--
		62033 +	--	908.4[15.83]	--	--
		Grab	--	750	--	--
1B & 3A	A/B-2	DM-47 +	--	--	256[22]	140.2[18.25]
		62797 +	--	--	288.4[22]	149.0[18.25]
1B & 3A	A/B-3	DM-41	--	--	267.4[20.75]	144.2[19]
		62790	--	--	425.7[20.75]	183.1[19]
		Grab	--	--	340	220
		Grab	--	--	365	176
		Grab	--	--	304	--

+ Parallel passive and active samples

VIII. Miscellaneous Observations

Three other noteworthy observations were made during the voyage that did not fall within one of the categories of ship operations previously discussed. These included:

- o Ship tank inspection by certified Marine Chemist and his assistants,
- o area monitoring of the deckhouse environment and
- o cargo line rupture during cargo transfer.

TABLE IV. CHARCOAL TUBE ANALYSES

Sample No.	T(°C)*	Duration (Min)	V(L)*	Compound*	W_c (μg)*	C(ppm)
TX-101	29.8	65	13.06	THC	37	0.82
				BNZ	<1	<0.024
				TOL	<1	<0.019
				HXA	<5	<0.11
TX-103	27.0	43	8.64	THC	<5	<0.16
				BNZ	<1	<0.036
				TOL	<1	<0.029
				HXA	<5	<0.16
TX-110	22.6	20	4.02	THC	169	11.8
				BNZ	<1	<0.076
				TOL	<1	<0.061
				HXA	11	0.76
TX-111	31.2	230	39.79	THC	2120	15.4
				BNZ	14	0.11
				TOL	39	0.25
				HXA	270	2.0
TX-118	31.7	145	28.71	THC	2055	20.8
				BNZ	13	0.14
				TOL	23	0.20
				HXA	243	2.4
TX-121	24.8	11	2.21	THC	23	3.0
				BNZ	<1	<0.14
				TOL	<1	<0.11
				HXA	<5	<0.64
TX-122	22.8	40	8.04	THC	356	12.5
				BNZ	1	0.035
				TOL	1	0.031
				HXA	22	0.76
TX-123	25.3	188	37.22	THC	616	4.7
				BNZ	2	0.016
				TOL	7	0.047
				HXA	55	0.42
TX-125	29.8	27	5.24	THC	61	3.4
				BNZ	<1	<0.059
				TOL	<1	<0.048
				HXA	<5	<0.27
TX-126	34.8	31	6.23	THC	4120	193.8
				BNZ	24	1.2
				TOL	38	1.6
				HXA	340	15.9
			HXA	43	2.0	

*See notes at end of table

The analytical chemistry results for the H_2S passive dosimeters and charcoal tubes are shown in Tables III and IV, respectively. The charcoal tube data reflect sampling temperature; pressure corrections were considered to be negligible. Where the analytical results did not exceed the detection limit, concentration was quantified at that limit.

TABLE III. ANALYSIS RESULTS FOR HYDROGEN SULFIDE PASSIVE DOSIMETERS

Sample No.	A_{net}*	Duration (hr)	C(ppm)	Sample No.	A_{net}*	Duration (hr)	C(ppm)
96302	0.019	4.43	0.33	96366	0.014	0.23	4.72
96303	0.011	1.25	0.68	96367	0.008	0.23	2.70
96304	0.007	0.53	1.02	96368	0.161	1.25	9.98
96305	0.006	0.48	0.97	96369	0.047	0.45	8.10
96306	0.009	0.78	0.89	96370	0.025	1.32	1.47
96307	0.008	0.72	0.86	96373	0.014	8.25	0.13
96308	0.030	3.83	0.61	96374	0.012	8.25	0.11
96309	0.024	2.40	0.78	96375	0.009	8.50	0.08
96310	0.021	1.42	1.15	96376	0.010	6.83	0.11
96311	0.009	0.18	3.88	96377	0.014	6.80	0.16
96312	0.011	0.18	4.74	96378	0.010	6.80	0.11
96313	0.015	0.18	6.46	96379	0.045	3.63	0.96
96314	0.009	0.22	3.17	96380	0.011	3.18	0.27
96361	0.025	0.33	5.87	96381	0.013	3.20	0.31
96362	0.231	1.38	12.98	96382	0.015	3.08	0.38
96363	0.054	1.13	3.70	96383	0.009	0.23	3.03
96364	0.024	1.13	1.65	96384	0.057	0.73	6.05
96365	0.009	0.23	3.03				

*A_{net} = net absorbance corrected for blank

$$C = \frac{A_{net}}{(\text{DURATION})(\text{CAL FACTOR})}$$

CAL FACTOR = 0.0129

downward correction to measured levels was applied on a selective basis with due regard for the proximity of the measurement point to the gas source (ullage port). The farther the measurement point is from source, the higher is the probability that interefent gases will be diluted to levels that have no affect on the indicated H_2S concentration. Prior to each use, the monitor was calibrated against a known span gas concentration.

An Organic Vapor Analyzer (OVA) was used to measure instantaneous vapor concentrations. This instrument is sensitive to all hydrocarbon vapors from crude oil including the lights end down to methane. The instrument was calibrated against a known concentration of methane prior to each use period. Following the test, the instrument was cross-calibrated against hexane so that instrument readings as methane could be converted to their hexane equivalent. This procedure facilitates comparison of total Hydrocarbon concentration as determined by the OVA with the total hydrocarbon concentration as determined by charcoal tube methods. The OVA data reflect the light end asphyxiants (methane thru butane) that are not trapped on charcoal. The reader should be aware that the designator THC is used in this report for both the OVA measurements and the "total hydrocarbon concentration" from the charcoal tubes. With the above discussion, there should be no difficulty in interpreting the data.

The American Conference of Governmental Industrial Hygienists indicates the following exposure limits for the measured contaminants.

Contaminant	TLV-TWA (ppm)	TLV-STEL (ppm)
Hydrogen Sulfide	10	15
Benzene	10	25
Toluene (skin)	100	150
Hexane	50	-

On the basis of these determinations, the desorption efficiency for THC was taken to be 100.0.

Direct reading, intrinsically safe, instruments were used to measure H_2S and hydrocarbon concentrations during various surveys as well as in the breathing zone of workers involved in cargo related activities.

The H_2S monitor uses an electrochemical sensor cell, and the instrument has a cross sensitivity to NO, NO_2, SO_2 and CO, which are constituents in flue gas inerting systems. The interferences are on the positive side, so selective downward adjustment of recorded levels was necessary. The correction amount was based on the assumption that the interferring effects of each constituent are additive. The interference equivalents are shown below.

Interferent Level	Interferent Equivalent H_2S (ppm)
10 ppm SO2	1
2 ppm NO	1
28 ppm NO2	1
1000 ppm CO	1

Based on data in the shipboard IGS Manual and discussions with domestic manufacturers/installers of IGS systems, the following constituent levels are representative of the gas state downstream of the scrubber.

SO2 - 300 ppm

NOx - <150 ppm

CO - <100 ppm

As the split between NO and NO_2 in the flue gas could not be determined, it was assumed that the entire NO_x contribution of 150 ppm was present as NO. This assumption yielded a worst-case correction for oxides of nitrogen. Applying the above cross-sensitivities to the flue gas interferents resulted in an H_2S correction factor of 105 ppm. This

IV. Sampling and Analysis

Two types of occupational exposure dosimeters were used:

- o Passive dosimeters for hydrogen sulfide and
- o NIOSH-approved charcoal tubes and battery operated pumps for organic vapors.

The battery operated pumps carried intrinsic safety certification and were operated at a nominal flow rate of 0.2 L/min. For calculation purposes, the flow rate was based on pre- and post-use calibrations.

The charcoal tubes were analyzed by an AIHA accredited laboratory. Head space analyses of the crude oils was used to identify the compounds of interest on the tubes. All tubes were analyzed by gas chromatography (GC) for benzene (BNZ), toluene (TOL), hexane (HXA), and total hydrocarbon (THC) through xylene expressed as hexane. Nitrobenzene was used as the desorbing solution because it elutes from the GC column after xylene, and thus does not interfere with or mask the presence of low molecular weight hydrocarbon vapors. Note that the lower molecular weight hydrocarbons (methane, ethane, propane, butane) are not trapped on charcoal, and thus do not contribute to the THC determination.

Charcoal tube desorption studies were conducted for BNZ, HXA and TOL using nitrobenzene as the desorbing solvent. The spiking levels were representative of the levels on the exposed tubes. Three replicate determinations were made at each level. The desorption efficiencies were as follows.

Compound	Desorption Efficiency (%)
BNZ	102.3
HXA	100.7
TOL	106.7

III. Cargo Description

Two different grades of crude oil were transferred during the voyage. Upon arrival at the first discharge terminal, the ship carried Maya crude. The status of the cargo tanks is shown in Table I. Subsequently, the ship was loaded with Isthmus crude. The post-loading status of the cargo tanks is shown in Table II. Isthmus crude was transferred to shore at the second discharge terminal.

TABLE I. STATUS OF CARGO TANKS PRIOR TO DISCHARGE OF MAYA CRUDE

Tank No.	Capacity, bbls	Discharge. bbls*	Percent Full+
1P	27557	23772	86.3
1S	27557	23803	86.4
1C	76662	57852	75.5
2C	85034	67329	79.2
3C	85034	67638	79.5
4C	42517	34890	82.1
5C	85034	68680	80.8
5P	27603	24859	90.0
5S	27603	23426	84.9
Slop P	20387	13222	64.8
Slop S	20387	13412	65.8
	525,375	418,883	79.7

* Contents discharged completely
\+ On arrival

TABLE II. STATUS OF CARGO TANKS AFTER LOADING ISTHMUS CRUDE

Tank No.	Capacity, bbls	Load bbls	Percent Full
1P	27557	25556	92.8
1S	27557	25613	92.9
1C	76662	62544	81.6
2C	85034	72409	85.2
3C	85034	77418	91.0
4C	42517	36129	85.0
5C	85034	74395	87.5
5P	27603	26009	94.2
5S	27603	26064	94.4
Slop P	20387	15845	77.7
Slop S	20387	14269	70.0
	525,375	456,261	86.8

II.7 Cargo Loading

- o closed, split drop
- o cargo transfer controlled remotely at mimic board in Cargo Control Room

II.8 Tank Cleaning Method

- o all cargo tanks were fitted with COW machines

II.9 Inert Gas System

- o the vessel was fitted with a flue gas inerting system in accordance with USCG regulations

II. Vessel Description

II.1 Dimensions

- o Length overall, 800 ft
- o Molded breadth, 100 ft

II.2 Tonnage

- o Summer draft - 68000 DWT

II.3 Cargo/Ballast Tanks

- o 11 crude oil cargo tanks
- o 6 dedicated ballast tanks

II.4 Cargo/Ballast Pumps

- o 3 main cargo pumps in pumproom
- o ballast water pump in pumproom
- o 1 stripping pump in pumproom

II.5 Cargo Gauging Method

- o closed gauging with remote ullage readout in Cargo Control Room during all phases of transfer
- o open gauging prior to and at the conclusion of loading and discharge as required by cargo surveyors

II.6 Vapor/Gas Venting

- o all cargo tanks vented through a single common, elevated mast riser vent (b/3) except when performing open gauging as described in II.5

I. Trip Overview and Objectives

The primary objective of this voyage was to monitor occupational exposures to organic vapors and hydrogen sulfide gas during sour crude oil operations. The round trip voyage lasted nine days. The project team boarded the vessel at the initial discharge terminal where Maya crude oil was transferred to shore. Following the ballast voyage, Isthmus crude oil was loaded onto the ship, This product was subsequently discharged at LOOP (Louisiana Offshore Oil Platform), the final terminal in the voyage.

Exposure monitoring began roughly midway into the discharge of Maya crude and continued through the predischarge gauging round at LOOP. This effort reflected operations that are unique to vessels equipped with flue gas inerting systems as well as operations that are common practice in the transport of other bulk liquids.

Occupational exposure monitoring was supplemented by area monitoring and the use of direct reading instruments for measuring instantaneous breathing zone concentrations of hydrogen sulfide and total hydrocarbon vapor. These instruments were also used in survey mode both on deck and in accommodation spaces.

VOYAGE 4 REPORT OUTLINE

I. Trip Overview and Objectives

II. Vessel Description

III. Cargo Description and Transfer Schedule

IV. Sampling and Analysis

V Pumproom Environment - Initial Discharge Terminal

VI. Tank Stripping - Initial Discharge Terminal

VII. Tank Depressurization Prior to Loading

VIII. Bottom Gauging Prior to Loading

IX. Product Loading

X. Instrument Surveys During Loading

XI. Tank Processing - End of Loading

XII. Tank Pressure Relief - Laden Voyage

XIII. Entry into Ballast Tanks

XIV. Tank Processing - Final Discharge Terminal

APPENDIX D

VOYAGE REPORT - VOYAGE 4

period of the first tube (08-P8) was started concurrently with the initiation of tank cleaning. Primary sources of infiltration were from discharge of tank vapors venting from tanks 3P, 3S, 5A, 5B, 7P and 7S. Two forward tanks 1A and 1D were also being ventilated over this time period. The second sample, SB-8, was taken toward the end of the tank cleaning operation two days later. The chemical concentration on these samples are shown below.

Sample No.	Chemical Concentration, ppm					
	ACT	TCE	DCM	TCL	TTE	STY
08-P8	--	4.5	9.9	ND	--	ND
SB-8	ND	ND	0.2	ND	ND	ND

Cargo Line Rupture

Rupture of two different cargo piping lines were observed. Both ruptures occurred during discharge of cargo when internal pipe pressures were the highest. The first rupture occurred in the cargo piping through which caustic was being discharged at the loading port. This line break was located in a section of piping that was below other cargo piping. The rupture was in an area not frequented by the deckwatch crew, and the piping above it shielded the release of this corrosive cargo. The product flow was stopped, and there were no injuries. The second rupture, which occurred at one of the discharge ports, was not as isolated as the first. The cargo that was being discharged through the line was lignin liquor, a relatively inocuous compound, which covered the aft port area of the deck.

Both ruptures were indicative of the condition of the cargo lines on the ship. Along with its biennial inspection, repair and/or replacement of a major portion of the ship's deck piping had been planned.

personal sample because the tanks that contained this chemical, 7P and 7S, had already been examined before the sample was started. In addition to these measurements, the Draeger tube measurements are also shown.

Chemical/Tank No./Concentration, ppm/[entry time, min]

Sample No.	ACT 2D	TCE 1A	TCE 5A	TCE 5B	TCL 1D	TTE 3A	EDC 1B	STY 3S	STY 3P
DM-40	ND ←	———	9.1	——→	5.7	5.3	9.2	←—— 0.7	—→
Draeger Tube	0	0	0	0	0	0	<5	<15	<15
Entry Time [min]	[1]	[1]	[2]	[1]	[1]	[1]	[2]	[2]	[2]

Deckhouse Environment

At various times during the voyage, the environment in the deckhouse was monitored for infiltration of chemical vapors. Most of the measurements were made with an Organic Vapor Analyzer (OVA). When the OVA was not available, samples were collected on personal sampling tubes located inside one of the SwRI personnel's quarters. OVA surveys taken during cargo loading, ballasting, and cargo discharge showed no apparent increase in the hydrocarbon concentration in the deckhouse above the normal background. Cross ship wind direction and tight sealing forward deckhouse doors helped eliminate the entry of chemical vapors during these ship operations.

During tank cleaning and ventilation, however, measureable increases in cargo vapors were observed in the deckhouse. Personnel sampling tubes were used to monitor the vapor infiltration during these activities. A total of two sample tubes were collected. The sampling

Ship Inspection by Marine Chemist

The inspection team that certified the ship gas free and ready for dry dock consisted of a Marine Chemist and his two assistants entitled "competent persons". Two types of inspections were performed to certify that the ship was gas-freed. The first inspection consisted of checking the contents of all cargo tanks and other enclosed spaces (cofferdams) for oxygen and combustible gas concentrations. This type of inspection was divided up between the Marine Chemist and the two competent persons. The Marine Chemist entered all tanks that had contained potentially dangerous chemicals (potentially dangerous chemicals were identical to those identified in the SwRI sampling plan) as well as all other tanks and cofferdams forward of the loading manifold. The "competent persons" inspected those tanks aft of the loading manifold. The measurement device that each used was a combination O_2/CG meter. The longest entry time was approximately three minutes, with the average being around 1.5 minutes. None of the inspectors wore any protective equipment except for cotton gloves and hard hats. After this initial inspection, the ship was cleared into the yard.

The second inspection was made when the ship arrived at the dock. During this inspection those tanks that had contained the "dangerous chemicals" were retested with a Draeger detector tube system. The Marine Chemist used the detector tube system with a drop line from the deck to test the atmosphere at the first platform level into the tank. If the atmosphere was acceptable, he entered the tank to the first platform level and repeated the drop line test. Entry times for these inspections were of short duration, lasting at most two minutes.

Occupational exposures were monitored on the Marine Chemist during these tank entries. The concentration of chemicals detected along with the entry times for each tank are shown below. DCM is not represented on the

TABLE IV. CHARCOAL TUBE ANALYSES (Continued)

Sample No.	T(°C)*	Duration (Min)	V(L)*	Compound	W_c (μg)*	C(ppm)
SC-4	27.0	31	6.26	THC	457	20.9
				BNZ	2	0.10
				TOL	2	0.08
SC-5	27.0	28	5.54	THC	247	12.7
				BNZ	1	0.056
				TOL	1	0.045
				HXA	21	1.1
SC-6	27.0	45	9.09	THC	73	2.3
				BNZ	1	0.034
				TOL	<1	<0.028
				HXA	<5	<0.16
SC-7	34.8	218	37.71	THC	6308	49.0
				BNZ	32	0.27
				TOL	58	0.40
				HXA	780	6.0
SC-8	24.8	11	2.22	THC	<5	<0.64
				BNZ	<1	<0.14
				TOL	<1	<0.11
				HXA	<5	<0.63
SC-9	25.3	185	37.37	THC	538	4.1
				BNZ	2	0.016
				TOL	6	0.04
				HXA	49	0.37
SC-10	34.8	20	4.02	THC	2970	216.5
				BNZ	15	1.2
				TOL	23	1.5
				HXA	290	21.0
SC-11	34.8	51	10.25	THC	11880	339.7
				BNZ	84	2.6
				TOL	110	2.8
				HXA	1845	52.4
SC-15	24.8	13	2.52	THC	<5	<0.56
				BNZ	<1	<0.12
				TOL	<1	<0.10
				HXA	<5	<0.56
X-17	22.6	80	16.16	THC	1940	33.8
				BNZ	15	0.28
				TOL	19	0.29
				HXA	200	3.5

*See notes at end of table

TABLE IV. CHARCOAL TUBE ANALYSES (Concluded)

Sample No.	T(°C)*	Duration (Min)	V(L)*	Compound	W_C (μg)*	C(ppm)
X-28	22.6	28	5.63	THC	3499	174.9
				BNZ	20	1.1
				TOL	24	1.0
				HXA	357	17.7
X-36	22.6	53	10.28	THC	2922	80.0
				BNZ	13	0.38
				TOL	20	0.48
				HXA	270	7.3
MC-28	22.6	26	5.23	THC	2045	110.0
				BNZ	10	0.58
				TOL	12	0.57
				HXA	170	9.1

NOTES:
1. Temperature in °C
2. V = Sample volume in liters
3. THC = Total hydrocarbon through xylene as hexane
   BNZ = Benzene
   TOL = Toluene
   HXA = Hexane
4. W_C = Weight of analyte corrected for blank

V. Pumproom Environment - Initial Discharge Terminal

At approximately midway into product discharge, the pumproom was surveyed for H2S gas concentrations. Gas concentrations were not detectible on descent into the pumproom or at the bottom of the pumproom.

An H_2S area monitor was installed at the bottom of the pumproom at a location that was representative of where the Pumpman would work while checking pump suction/pressure and the separators/air extractors. The area monitor results are shown below.

Sample No.	H_2S (ppm)	Duration (min)
96302	0.33	266

During ascent from the pumproom, an H_2S concentration of 1 ppm was measured by direct reading instrument.

VI. Tank Stripping - Initial Discharge Terminal

Throughout the majority of the discharge operation, the closed gauging systems were used to monitor tank ullage at the mimic board in the Cargo Control Room. At the final stage of discharge, the tank stripping systems were brought on-line to maximize the quantity of product transferred to shore. During the stripping operation, the closed, remote gauging of tank ullage was replaced by manual open gauging in order to improve the accuracy of the measurements.

All ullage ports were closed during the bulk of the discharge because the inert gas system was in operation. The system maintained a common positive pressure of 500-700 mm H_2O in all of the tanks. When a given ullage port was opened for gauging by the Quartermaster and an O/S, the entire system depressurized through that port because the other tank ullage ports were closed. While the system was depressurizing, both crew members generally stood upwind and away from the port. The length of the blowdown time before gauging could be initiated was variable and was a function of the initial tank pressure. Maximum blowdown time was 11 minutes. Blowdown time tended to become shorter as successive tanks were gauged because the inert gas pressure had not had sufficient time to recover to the operating range. Correspondingly, vapor and gas discharge flow rates varied directly with tank pressure.

The decision to approach the ullage port and initiate gauging was based on judgement. The Quartermaster functioned as an observer; the O/S did the manual gauging. The gauging tool consisted of a graduated rod at the end of a tether line. The gauging procedure involved lowering the rod into the tank until it touched the tank bottom and then retrieving the tether until the rod was close to the ullage port. During this part of the operation, the O/S's breathing zone was two to three feet from the centerline of the ullage port. The O/S would then move toward the ullage

port, remove the rod from the tank and read the gauge. In this phase of the operation, his breathing was generally 1-1.5 feet above the ullage port. The Quartermaster observed and verified the reading. The number of ullage readings per tank was variable and ranged from five to a maximum of 18 over a 20-minute period on Tank SP.

Shown below are the tanks where bottom gauging was observed and monitored. Also shown are the times when ullage ports were opened and the gauging was completed.

Tank No.	Time Open	Time Finish
1C	1139	1204
3C	1312	1322
5P	1322	1328
5C	1403	1427
SP	1428	1443

When the gauging was completed, the ullage port was closed and secured. With one exception, which will be discussed later, only one ullage port was open at any time.

H_2S concentrations were measured at selected tanks using direct reading instrumentation. Those measurements are summarized below.

Tank No.	Concentration (ppm)	Location
1C	19-32	O/S Breathing Zone
1C	1395-1893	Ullage Port
SP	3-5	Ullage Port
3C	50-595	O/S Breathing Zone
5P	195	Ullage Port
5C	20-70	O/S Breathing Zone

The background levels of H_2S around each tank ranged from 2-5 ppm.

Occupational exposure samples were collected on the Quartermaster and the O/S. In the case of the Quartermaster, the samples coincided with the gauging of tanks 5C and SP. The results are presented below.

Quartermaster

Sample No.	Duration(min)	H_2(ppm)	THC*(ppm)	HXA(ppm)	BNZ(ppm)	TOL(ppm)
96303	75	0.68	--	--	--	--
TX-122	40	--	12.5	0.76	0.035	0.031

* Total hydrocarbon concentration as hexane

The O/S was monitored for H_2S exposure during the bottom gauging of tanks 5P, 5C and SP.

O/S

Sample No.	Duration (min)	H_2S(ppm)
96310	85	1.15

Normally, only one ullage port was open at a given time. In the case of tank 5P, the ullage port was open for a period of time around 1156 hours, during which tank 1C was also open. At this time, stores were being loaded onto the ship and manually transported to the deckhouse past the open ullage port on 5P. Up to seven crew members were involved in this activity. The walkway past the expansion trunk was roughly nine feet downwind of the ullage port. H_2S concentration at the walkway was 8 ppm. Source concentrations were 55-180 ppm one foot above the plane of the ullage port.

During the depressurization and gauging activities, the odor of H_2S was present in the lower level of the deckhouse and a concentration of 2 ppm was measured on the Captain's Deck level.

VII. Tank Depressurization Prior to Loading

All tanks were depressurized from 900 mm H_2O prior to entering the waterway leading to the loading port. The ship executed a 360° turn under low power during the depressurization. Consequently, the wind direction on the deck was variable - beginning and ending in a port/starboard direction. During the 24-minute blowdown, anemometer readings indicated a wind speed of roughly 35 mph.

The Chief Mate opened the manual valve on the vent riser at 1732. At 1750, he opened the ullage port on tank 1S to speed up the blow down. The Chief Mate's exposure to H_2S and organic vapors was monitored with dosimeters. The results are shown below.

Sample No.	Duration(min)	H_2S(ppm)	THC*(ppm)	HXA(ppm)	BNZ(ppm)	TOL(ppm)
SC-4	31	--	20.9	2.0	0.10	0.08
94304	32	1.02	--	--	--	-

* Total hydrocarbon concentration as hexane

Dosimeters were also worn by the members of the project team. The measured exposures are presented below.

Sample No.	Duration(min)	H_2S(ppm)	THC*(ppm)	HXA(ppm)	BNZ(ppm)	TOL(ppm)
SC-5	28	--	12.7	1.1	0.056	0.045
96305	29	0.97	--	--	--	-

* Total hydrocarbon concentration as hexane

One project member wore Sample No. SC-5 while he accompanied the Chief Mate. Sample No. 96305 was worn by another project member who surveyed the deck for H_2S concentrations using a direct reading instrument.

Survey measurement points were downwind of the elevated vent to determine if the discharge plume returned to the deck. With one exception, the wind conditions (speed and direction) did not permit the plume to return to the deck; H_2S concentrations were not detectible. In the one exception, a 12 ppm H_2S reading was obtained atop the first fire station platform forward of the deckhouse. The wind was in a bow to stern direction. At the time that this reading was taken, a concentration of 3 ppm was measured on the bridge wing.

When the Chief Mate opened the ullage port on tank 1C, his breathing zone concentration of H_2S was 25 ppm. The concentration at the ullage port was of the order of 95 ppm H_2S.

VIII. Bottom Gauging Prior to Loading

Roughly four hours prior to the start of loading, the inert gas pressure head in the tanks was relieved by opening the manual valve on the common vent riser. Following the depressurization, the valve was closed, and the ship proceeded to the loading terminal where independent surveyors gauged residual oil and water levels on the tank bottoms. The two surveyors were accompanied by the Third Mate and the Assistant Bosun. At each tank, the Assistant Bosun's job was to open and close the ullage port. The Third Mate verified and recorded the surveyors' ullage readings. Both crew members stood upwind of the open ullage ports. At each tank, direct reading instrumentation was used to measure the instantaneous H_2S and total hydrocarbon concentrations at the open ullage port and in the Assistant Bosun's breathing zone when he opened the ullage port. The results are summarized in Table V.

Each of the crew members wore dosimetry equipment during the gauging round. The measured occupational exposures are presented below

Sample No.	Duration(min)	H_2S Conc. (ppm)	THC* (ppm)	Crew Member
96306	47	0.89	--	3M
TX-103	43	--	<0.16	3M
96307	43	0.86	--	Ass't Bosun
SC-6	45	--	2.3	Ass't Bosun

* Total hydrocarbon concentration as hexane

TABLE V. INSTANTANEOUS BREATHING ZONE AND SOURCE CONCENTRATIONS DURING GAUGING PRIOR TO LOADING

Tank No.	Time Start	Time Finish	H_2S Source	THC Source	H_2S BZ	THC BZ
5S	2006	2008	ND	NM	ND	8
SS	2010	2012	ND	NM	ND	8
5C	2013	2018	ND	to 2600	ND	8
3C	2020	2022	ND	10-1200	ND	8
1S	2024	2026	ND	10-2300	ND	8
1C	2027	2028	5-15	10-3700	ND	8
1P	2030	2031	ND	to 2300	ND	8
2C	2032	2035	ND	8	ND	8
4C	2036	2038	ND	8	ND	8
5P	2040	2044	ND	8	ND	8
PS	2045	2049	8-65	8	ND	8

Notes:
1. All concentration in ppm
2. THC - total hydrocarbon concentration as hexane
3. BZ - breathing zone, Assistant Bosun
4. ND - not detectable
5. NM - not measured

IX. Product Loading

Product tanks were inerted during discharge. The tanks were sealed and isolated such that the state of the inert gas in the tanks should have remained essentially constant throughout the ballast voyage. At the loading port, tanks were loaded beneath this inert blanket. Product vapors and inert gas were vented through a common, elevated mast riser. All cargo tanks had closed gauging systems with remote readout in the Cargo Control Room.

The closed, remote gauging systems were used at all times. As a result, the cargo transfer watches consisted of a Mate in the Control Room and an A/B whose function was to tour the deck and be alert for any equipment/system malfunctions. The A/B on watch also performed minor maintenance activities such as adjusting and jacketing turnbuckles on the port and starboard gangways. Periodically, the Pumpman gauged the segregated ballast tanks. Basically, there was minimal crew activity on deck during loading.

At 11 hours into the 19-hour loading period, organic vapor and H_2S dosimetry equipment was fitted to the A/B on the 0800-1200 watch. The exposure results are summarized below.

Sample No.	Duration(min)	H_2S(ppm)	THC*(ppm)	HXA(ppm)	BNZ(ppm)	TOL(ppm)
96308	230	0.61	--	--	--	--
TX-111	230	--	15.4	2.0	0.11	0.25

* Total hydrocarbon concentration as hexane

During that same watch, a member of the project team wore comparable dosimetry equipment. The exposure results are as follows.

Sample No.	Duration(min)	H_2S(ppm)	THC*(ppm)	HXA(ppm)	BNZ(ppm)	TOL(ppm)
96309	144	0.78	--	--	--	--
TX-118	145	--	20.8	2.4	0.14	0.20

* Total hydrocarbon concentration as hexane

Throughout this sampling period, the deck was surveyed for H_2S concentrations using direct reading instruments. The purpose of these surveys was to detect if the vented vapor/gas plume returned to the deck as a result of ambient wind conditions. During the initial surveys, the wind was starboard to port at an estimated 4-5 knots. Under these conditions, the plume did not return to the deck. The odor of H_2S was present, but instrument readings did not exceed 1 ppm. Subsequently, there was a wind shift (from roughly 30° off of the starboard bow). Under these conditions, the vented plume returned to the deck at approximately 200 feet aft of the vent and at the port gangway. H_2S concentrations ranged from 34 to 80 ppm.

Area monitoring for H_2S infiltration was conducted in the Deckhouse throughout the entire loading. The loading was divided into three monitoring periods. In each period, a monitor was located in the Pilot's cabin, which was on the Captain's Deck level. Two monitors were always in place in the Cargo Control Room. One monitor was located roughly eight inches below the ceiling, the second monitor was about 30 inches above the floor. The results are summarized below in the order in which the samples were collected.

Pilot's Cabin

Sample No.	Duration(min)	H_2S(ppm)
96375	510	0.08
96376	410	0.11
96382	185	0.38

Cargo Control Room

Sample No.	Duration(min)	H_2S(ppm)	
96373	495	0.13	
96378	408	0.11	High
96380	191	0.27	
96374	495	0.11	
96377	408	0.16	Low
96381	192	0.31	

During roughly the last three hours of loading, organic vapor area monitors were also located in the Cargo Control Room and the Pilot's Cabin. These monitors served to assess the level of vapor infiltration into the Deckhouse at a time when discharge concentrations were at a maximum at the vent riser. The results are shown below.

Cargo Control Room

Sample No.	Duration(min)	THC*(ppm)	HXA(ppm)	BNZ(ppm)	TOL(ppm)
SC-9	185	4.1	0.37	0.016	0.04

* Total hydrocarbon concentration as hexane

Pilot's Cabin

Sample No.	Duration(min)	THC*(ppm)	HXA(ppm)	BNZ(ppm)	TOL(ppm)
TX-123	188	4.7	0.42	0.016	0.049

* Total hydrocarbon concentration as hexane

X. Instrument Surveys During Loading

Loading of Isthmus crude commenced at 2100 hours and was completed at 1600 hours of the next day. Midway through the loading period, three consecutive surveys were conducted.

- o Survey No. 1 - Deck survey to measure H_2S and THC concentrations at breathing zone elevation above the deck. Measurements were made in the vicinity of tank expansion trunks and hose manifolds.

- o Survey No. 2 - This survey was conducted to detect gas and vapor leakage at the ullage port and dome seals on tank expansion trunks.

- o Survey No. 3 - Passageways on the five levels of the deckhouse and the bridge were surveyed for infiltration of H_2S and cargo vapors.

During these surveys, loading of 1P, 1S, 5P, 5S, Slop P and Slop S tanks was completed, and the total flow of cargo was being transferred to the center tanks. All cargo vapors were vented through the single common mast riser that was located forward of the 2C expansion trunk. Qualitatively, the wind was very calm in a generally bow to stern direction (one point off of port bow). Tables VI, VII and VIII summarize the results of the surveys.

Two occupational exposure samples were collected during ballast tank nspection. Sample No. TX-125 was collected on the Quartermaster during ntry into Tank 3P and 3S. Total intank time was 20 minutes out of a 27-inute sample duration. The second sample, TX-101, was worn by a member f the SwRI project team who accompanied the Chief Engineer on all ntries. Total entry time for the Chief Engineer was about 60 minutes out f a 65 minute sample duration. The results are summarized below.

Sample No.	Duration (min)	THC* (ppm)
TX-125	27	3.4
TX-101	65	0.82

* Total hydrocarbon concentration as hexane

XIII. Entry into Ballast Tanks

During the laden voyage, there was an indication of a leak in the deck hydraulic system. The suspected source of the leak was in the ballast piping where the hydraulic lines penetrate below deck bulkheads on the ballast tanks. To assess the situation, the Chief Mate, Chief Engineer and Quartermaster, and the Assistant Bosun collectively entered all six segregated ballast tanks and the forepeak fresh water ballast tank. These entries revealed that the leak was not in the hydraulic system for the ballast tanks. The entry procedure that was used is documented below.

Initially, the access ports on all tanks were opened, and each tank atmosphere was tested sequentially for oxygen concentration. Testing was under the direction of the Chief Mate. A Reiken oxygen meter was used with a 21m dropline that extended 18m into the tank. Measurements were made through one opening on each tank and at one depth into the tank. SwRI conducted independent, parallel measurements with an MSA Model 260 combination oxygen/combustible gas meter. In all cases, the oxygen concentration was 20.8% v/v as measured with the MSA Model 260.

Because the tanks had not carried cargo, the tank atmospheres were not tested for combustible gas concentrations. Using an OVA, SwRI measured total hydrocarbon concentrations of seven to 15 ppm (as methane) inside the expansion trunk coming just beneath the weather deck.

The four crew members that were identified above did not generally enter and inspect each of the seven tanks as a group. The number and title of the crew members entering a given tank varied. On occasion, the group divided and multiple tanks were inspected simultaneously. As the overall responsibility rested with the Chief Engineer, he entered all of the tanks. Entry time per tank ranged from seven to 12 minutes. Tank ventilation was not provided during entry. A deck-side safety watch was not always present at each entry.

- 50 ppm THC and 1 ppm H_2S in front of port storehouse.
- 1900 ppm THC and 32 ppm H_2S at the port manifold.
- 50 ppm THC and 6 ppm H_2S near the expansion trunk on tank 4P.

The crew member in charge of the relief valve, sat on the catwalk upwind of the vent during depressurization.

Area monitors for H_2S and THC were located in the Cargo Control Room. The results are shown below.

Sample No.	Duration (min)	Concentration (ppm)
SC-8	11	<0.64 (THC*)
96311	11	3.88 (H_2S)

* Total hydrocarbon concentration as hexane

The SwRI project member wore H_2S dosimeter No. 96313 while he was on deck during the pressure relief. Over the 11-minute sampling period, the exposure level was 6.46 ppm.

Pressure Relief Episode No. 4

On approach to the discharge terminal, all tanks were depressurized using the manual method described above. Nocturnal cooling had reduced tank pressure to 700 mm H_2O at 1028 when the relief valve was opened. The blowdown continued until 1036 when the pressure stabilized at 200 mm H_2O. As the depressurization was unannounced, there was no opportunity to measure H_2S or THC concentrations. There was a definite odor of H_2S on the Captain's Deck and in the Cargo Control Room.

<u>Pressure Relief Episode No. 3</u>

- o Fresh air inlets to deckhouse closed
- o Relief valve opened at 1006; line pressure 1500 mm H20
- o Wind 18 knots from 50° off of the starboard bow
- o Doors to bridge wings closed at all times
- o No measurable H_2S concentration in wheelhouse or on bridge wings
- o Relief valve closed at 1016; line pressure 700 mm H_2O
- o Fresh air inlets to deckhouse opened

During this episode, H_2S and total hydrocarbon (THC) area monitors were installed in the Pilot's stateroom. The results are summarized below.

Sample No.	Duration (min)	Concentration (ppm)
96314	13	3.17 (H_2S)
SC-15	13	<0.56 (THC*)

* Total hydrocarbon concentration as hexane

In addition, H_2S and THC dosimetry equipment was worn on the bridge by an SwRI project member. The results are as follows.

Sample No.	Duration (min)	Concentration (ppm)
96312	11	4.74 (H_2S)
TX-121	11	3.0 (THC*)

* Total hydrocarbon concentration as hexane

Background concentrations of 8 ppm THC and 0 ppm H_2S were recorded prior to valve opening. After valve opening, the following concentrations were recorded.

Instrument surveys for total hydrocarbon and H_2S concentrations were made on deck during the depressurization. The results are summarized below.

- o Prior to valve opening, the general background concentrations were 8 ppm THC and 0 ppm H_2S.
- o Four minutes after valve opening, 3-5 ppm H_2S and 200 ppm THC were recorded at the catwalk by the loading hoses.
- o Six minutes into the pressure relief, 400 ppm THC and 11 ppm H_2S were measured at the SS tank.
- o One minute later, 1200 ppm THC and 31-39 ppm H_2S were measured next to the 5P tank expansion trunk.
- o At eight minutes into the pressure relief, 250 ppm THC and 23 ppm H_2S were measured at the port winch just aft of the PV breaker.
- o At the PV breaker the THC and H_2S concentrations were 400 ppm and 48 ppm, respectively.
- o Concentrations declined to the background levels after the valve was closed.

Three passive dosimeters were used as area monitors in the deckhouse to detect H_2S infiltration. These area monitors were located at breathing zone height. An H_2S dosimeter was also worn by the crew member who opened and closed the vent valve and remained on deck during pressure relief. The results are presented below.

Sample No.	Type	Location	H_2S (ppm)	Duration (min)
96365	Area	Pilot's Cabin	3.03	14
96366	Area	Cargo Control Room	4.72	14
96367	Area	Wheel House	2.70	14
96383	Personal	--	3.03	14

- Fresh air intakes to deck house closed at 0803
- H_2S concentration on bridge wing was 8-10 ppm when the line pressure was 300 mm H_2O
- Relief valve closed at 0816
- H_2S concentration in the wheelhouse at 0823 was 3 to 4 ppm as a result of infiltration through the ventilation system

During the depressurization, H_2S concentrations were measured at various points on deck.

- H_2S was not detected beneath the vent riser which was located roughly midway between the 1C and 2C expansion trunks.
- 8-12 ppm H_2S on walkway over manifold deck piping (approximately 10 feet above the deck).
- 31 ppm H_2S on the starboard side of the intersection of tanks 4C and 5C. The Bosun and Chief Engineer were working on hydraulic lines at this location
- 20-25 ppm H_2S near the 5C expansion trunk
- 26-30 ppm H_2S near the SS tank expansion trunk which was located just forward of the deckhouse
- H_2S levels fell to zero after the vent valve was closed

Pressure Relief Episode No. 2

- Wind bow to stern at 22 knots
- Fresh air intake for deckhouse closed at 1256
- Doors to bridge wings closed at all times
- Relief valve opened at 1259; line pressure 1350 mm H_2O
- H_2S concentration on starboard bridge wing was 3 to 5 ppm
- H_2S concentration on port bridge wing was nominally 6 to 8 ppm with an instantaneous maximum of 16 to 17 ppm
- Relief valve closed at 1308; line pressure 600 mm H_2O
- Deckhouse fresh air vent opened at 1309

XII. Tank Pressure Relief - Laden Voyage

During the laden voyage, gas pressure in the ullage space above the cargo increases as a result of deck heating and cargo sloshing. The gas pressure in each tank is uniform because all tank isolation valves are open to the inert gas deck main, the deck main isolation valve is closed and the breather and bypass valves on the forward, common vent riser are closed. The pressure could be released automatically through a P/V valve or by manually activating a parallel valve. The manual method was used.

Pressure was relieved periodically on the laden voyage when the pressure approached the high alarm level of 1400 mm H_2O. Gas and vapor venting through the elevated mast riser continued until the inert gas main line pressure was reduced to roughly 300-400 mm H_2O. The valve was then manually closed. This operation involved one crew member who operated the valve and remained at the valve site during the pressure relief. Directions were received from the bridge by walkie-talkie.

During pressure relief, H_2S and total hydrocarbon area monitors were installed in the cargo control room and in the wheel house. Portable H_2S monitoring equipment was used on-deck on the bridge wings and in the wheel house. Personal dosimetry was also performed on the crew member who operated the bypass valve. The objective of the measurements was to assess the potential for gas and vapor exposures on the deck and in the accommodation spaces as a result of infiltration. The results of these measurements are summarized below.

Pressure Relief Episode No. 1

- Wind bow to stern at 21 knots
- Relief valve opened at 0801; line pressure 1350 mm H_2O
- H_2S concentration on the bridge wing after valve opening was nominally 27-30 ppm with a maximum of 37 ppm
- Doors to the wheelhouse from the bridge wings closed at all times

surveyors while they collected product samples from 1P, 1C, 1S, 5P and 5S. In this activity, the Quartermaster opened the ullage ports, stood back while the tanks depressurized and the surveyors collected their samples and then closed the ullage ports. Full watch occupational exposure samples for organic vapors and H_2S were collected on the Quartermaster. These samples reflect his exposure during product sampling and the final ullage round. The results are shown below.

Sample No.	Duration (min)	H_2S (ppm)	THC* (ppm)	HXA (ppm)	BNZ (ppm)	TOL (ppm)
SC-7	218	--	49.0	6.0	0.27	0.40
96379	218	0.96	--	--	--	--

*Total hydrocarbon concentration as hexane

Occupational exposure monitoring was conducted during the tank processing activity. The results are summarized below.

Assistant Bosun - Period I

Sample No.	Duration (min)	H_2S (ppm)	THC* (ppm)	HXA (ppm)	BNZ (ppm)	TOL (ppm)
SC-10	20	--	216.5	21.0	1.2	1.5
96361	20	5.87	--	--	--	--

* Total hydrocarbon concentration as hexane

Assistant Bosun - Period II and III

Sample No.	Duration (min)	H_2S (ppm)	THC* (ppm)	HXA (ppm)	BNZ (ppm)	TOL (ppm)
SC-11	51	--	339.7	52.4	2.6	2.8
TX-126	31	--	193.8	15.9	1.2	1.6
96362	83	12.98	--	--	--	-

* Total hydrocarbon concentration as hexane
Note: SC-11 and TX-126 are consecutive samples.

Period III

Sample No.	Duration (min)	H_2S (ppm)	Individual
96363	68	3.70	2M
96364	68	1.65	SwRI

Note: Monitor on SwRI employee who measured Assistant Bosun's breathing zone concentrations with direct reading instruments.

The Quartermaster was on watch from 1200-1600 hours, which included the end of loading. As indicated earlier, he was one of three crew members who were involved in the final ullage gauging with the product surveyors. Earlier in the watch, the Quartermaster accompanied the

surrounding deck structures shielded the work area from the ambient wind and did not permit vapor to be transported away from the work area. During the gauging round, direct reading instruments were used to measure gas and vapor concentrations in the Assistant Bosun's breathing zone. As before, these instantaneous grab sample measurements were made at the time when the maximum concentration was anticipated. Therefore, the concentration data that are summarized in Table X should not be assumed to be constant over the time interval at each tank.

TABLE X. BREATHING ZONE CONCENTRATIONS DURING ULLAGE ROUND WITH SURVEYORS AT END OF LOADING

Tank No.	Time Open*	Time Close*	H_2S (ppm)	THC (ppm)+
5S	1432	1440	5-100	>4000
SS	1441	1447	140	>4000
5C	1448	1452	455	>4000
3C	1453	1459	32-495	>4000
1S	1501	1505	75	>4000
1C	1505	1510	175	>4000
1P	1511	1516	42	>4000
2C	1516	1521	35	910
4C	1522	1527	109	>4000
5P	1528	1533	3	15
PS	1534	1539	130	>4000

* Ullage port opening and closing times
\+ Total hydrocarbon concentration as hexane

TABLE IX. BREATHING ZONE CONCENTRATIONS DURING THERMOMETER INSERTION INTO CARGO TANKS

Tank No.	Time Open**	Time Close**	H_2S (ppm)*	THC (ppm)*+
		PERIOD I		
5P	1336	1337	95	1900
SP	1337	1339	4	17
4C-aborted	1339	1341	4	20
1P	1342	1344	3	16
1S	1345	1347	4-11	15-910
5C	1348	1350	4	15-20
SS	1350	1351	145-445	500->4000
5S	1352	1353	10	100
		PERIOD II		
4C	1415	1416	1	15
2C	1417	1418	1	15
3C	1419	1420	1	15

** Ullage port opening and closing times
* Instantaneous grab samples. Constancy over time/tank should not be inferred.
+ Total hydrocarbon concentration as hexane

o Period III involved three crew members and a group of shore-based independent cargo surveyors. The crew members were the Second Mate, Assistant Bosun and the Quartermaster. These three individuals accompanied the surveyors to each tank where the surveyors measured cargo temperature and gauged the tanks for cargo and residual water content. During this operation, the Assistant Bosun opened the ullage port and retrieved the thermometer from the tank by winding the tether onto a spool. The 2M verified and recorded the surveyors measurements while the Quartermaster was responsible for closing the ullage port and wiping up any spilled oil with rags. During the majority of these operations, the crew members stood upwind or crosswind of the ullage ports. On occasion, this practice was not possible because of physical constraints imposed by deck piping or because

XI. Tank Processing - End of Loading

The processing of cargo tanks at the end of loading involved three distinct periods of activity.

- Period I included the time between 1333 and 1352 hours. During this time period, the Assistant Bosun went to each cargo tank, except 2C and 3C, opened the ullage port, lowered a tethered thermometer into the cargo and then closed the ullage port. This operation was attempted at 4C but was aborted because loading of the 2, 3, and 4 center tanks was still in progress. The ullage port on 4C was opened, but insertion of the thermometer was not possible due to the intensity of the vapor discharge plume. The loading of all other tanks had been completed.

  At each tank, the Assistant Bosun opened the ullage port and quickly moved to an upwind position until excess tank pressure had been partially relieved. During thermometer insertion his breathing zone was generally two feet above and two feet crosswind or upwind of the ullage port opening. Direct reading instruments were used to measure his instantaneous breathing zone concentrations of H_2S and total hydrocarbon at a time when the maximum concentration level was anticipated. The results are summarized in Table IX.

- Period II began at 1415 hours when the loading of 2C, 3C and 4C had been completed. The Assistant Bosun returned to these tanks to insert thermometers into the cargo space. His procedure was the same as described above. Breathing zone measurements for this activity are also shown in Table IX.

TABLE VIII. DECKHOUSE SURVEY

Level	H_2S (ppm)	THC* (ppm)	Status of Port and Starboard Access Doors
Main Deck	↑	12	Port Open - Stbd Closed
Boat Deck		18-20	Closed
Lower Bridge	Not	18	Closed
Upper Bridge	Detectable	15	Closed
Captain		16	Closed
Bridge	↓	18	Closed

* Total hydrocarbon concentration as hexane.

Note: Access door did not have a positive seal. Infiltration cracks were apparent around the jamb.

TABLE VI. DECK SURVEY OF GAS AND VAPOR CONCENTRATION AT BREATHING ZONE HEIGHT DURING LOADING

Tank No. or Location	H_2S (ppm)	THC* (ppm)
1P		10
1C		8
1S		8
2P		10
2C	Not Detectable	10
2S		8
Port Manifold		8
Starboard Manifold		10
4P		9
4S		10 to 50
5P		10
5S		20

*Total hydrocarbon concentration as hexane

General total hydrocarbon background = 8 ppm

TABLE VII. LEAK DETECTION SURVEY OF ULLAGE PORT AND DOME SEALS

Tank No.	Ullage Port		Dome	
	THC* (ppm)	H_2S (ppm)	THC* (ppm)	H_2S (ppm)
1P	15	ND+	ND	ND
1S	10	1	ND	ND
1C	≤910	≤8	ND	ND
2C	30	ND	ND	ND
3C	**	**	**	**
4C	>4000	≤1895	ND	ND
5C	>4000	≤ 104	10	10
5P	10	ND	ND	ND
5S	10-50	ND	10	10
Slop Port	≤910	12-20	ND	ND
Slop Stbd	≤910	20-25	10	ND

* Total hydrocarbon concentration as hexane

** Distinct leaks not discernable because the gas and vapor plume from the mast riser vent descended to the region around the 3C expansion trunk.

\+ ND - Not detectable

XIV. Tank Processing - Final Discharge Terminal

Prior to start of discharge, an independent cargo surveyor boarded the vessel to gauge all cargo tanks for oil and water content. The Chief Mate, Assistant Bosun and an A/B accompanied the surveyor on the gauging round. The C/M's duty was to verify the surveyor's measurements. The Assistant Bosun opened and closed the ullage ports. Because the gauging took place at night, the A/B held a flashlight so that the surveyor and the C/M could read the ullage tape.

After the Assistant Bosun opened the ullage port, he consistently attempted to take up a position several feet upwind or crosswind of the expansion trunk and out of the vapor plume. He was able to accomplish this on the majority of the tanks except for those that were not affected by the prevailing wind or where movement was constrained by deck piping.

The gauging operation had two parts. Initially, the surveyor gauged the depth of the oil free surface. After this was completed, the surveyor lowered the gauging bob to the tank bottom to measure residual water content. From several feet away, the surveyor reeled in the bob until it was near the tank top; he then approached the ullage port, finished the reeling process and read the water level on the graduated bob. During both of these gauging operations, the Chief Mate was next to the surveyor. At the ullage port, the Chief Mate's breathing zone was nominally one to three feet from the open port. The smaller distance coincided with reading of the tape or bob scale. During these observations, the Chief Mate frequently had to take up his position downwind of the ullage port, which was within the plume that was being discharged from the ullage port. At three ullage ports, the intensity of the gas and vapor plume exposure caused the C/M to cough, gag, expectorate and move away from the expansion trunk. In response to these encounters, the C/M shielded his nose and mouth with his arm when he returned to the tank. On two other occasions, he used the same shielding procedure when approaching a ullage port so as to prevent the exposure reaction.

The A/B who held the flashlight would stand behind the C/M and surveyor or to either side of one of them when the tape was being read. At the various tanks, these positions placed him upwind, crosswind or downwind of the vapor plume and generally within one to four feet of the ullage port.

At each tank, the Chief Mate's breathing zone concentration of H_2S and total hydrocarbon was measured at a time when the maximum level was anticipated. These data are presented in Table XI. In addition, occupational exposure monitoring was performed on the Chief Mate, Assistant Bosun and the A/B, and the results are summarized below. The sampling periods shown below can be correlated with gauging times in Table XI. Note that all concentrations are in ppm.

Chief Mate

Sample No	Time Start	Time Stop	H_2S	THC*	HXA	BNZ	TOL
X-28	0019	0047	-	174.9	17.7	1.1	1.0
TX-110	0048	0108	-	11.8	0.76	<0.076	<0.061
MC-28	0112	0138	-	110.0	9.1	0.58	0.57
96384	0024	0108	6.05	-	-	-	-
96369	0111	0138	8.10	-	-	-	-

* Total hydrocarbon concentration as hexane

Assistant Bosun

Sample No	Time Start	Time Stop	H_2S	THC*	HXA	BNZ	TOL
X-17	0019	0139	-	33.8	3.5	0.28	0.29
96370	0020	0139	1.47	-	-	-	-

* Total hydrocarbon concentration as hexane

AB

Sample No	Time Start	Time Stop	H_2S	THC*	HXA	BNZ	TOL
X-36	0059	0152	-	80.0	7.3	0.38	0.48
96368	0037	0152	9.98	-	-	-	-

*Total hydrocarbon concentration as hexane

TABLE XI. CHIEF MATE'S INSTANTANEOUS BREATHING ZONE CONCENTRATIONS DURING ULLAGE ROUND AT DISCHARGE TERMINAL

Tank No.	Time Open+	Time Closed+	H_2S (ppm)	THC (ppm)*
5P	0020	0027	945	NM
SP	0028	0032	1295	>4000
4C	0032	0038	375	>4000
2C	0040	0048	95-1895	>4000
1P	0049	0054	30	910
1C	0054	0101	>1895	>4000
1S	0102	0106	5-95	50-1500
3C	0113	0119	125-195	>4000
5C	0119	0127	595	>4000
SS	0128	0135	65	>4000
5S	0135	0138	20	NM

+ Ullage port opening and closing times
* THC - Total hydrocarbon concentration as hexane

Gauging of the final tank was completed at 0138. Between 0138 and 0152, the A/B helped the surveyor collect product samples from tanks 4C and 5P. Maximum breathing zone concentrations of H_2S and total hydrocarbon were greater than 1895 ppm and greater than 4000 ppm, respectively.

APPENDIX E

VOYAGE REPORT - VOYAGE 5

VOYAGE 5 REPORT OUTLINE

I. Voyage Overview and Objectives

II. Vessel Description

III. Cargo Description and Transfer Operations

IV. Sampling Strategy and Sample Analysis

V. Tank Washing

VI. Tank Entry

VII. Open Tank Gauging

I. Voyage Overview and Objectives

The objective of this voyage was to monitor occupational exposures of Deck Department personnel to product vapors during tank washing, tank entry and open tank gauging of cargo ullage during product loading. Transfer hose connect/disconnect was not monitored because this task was performed by terminal personnel rather than by members of the deck crew. Exposure monitoring during cargo discharge operations was not a voyage objective because of the low exposure potential.

A wide variety of cargos were handled throughout the voyage. The cargos that were selected for exposure monitoring were those that had

- o the potential for generating measurable airborne concentrations,
- o existing exposure limits,
- o established sampling and analysis procedures and
- o identifiable components of interest in the case of products that were complex mixtures.

II. Vessel Description

II.1. Dimensions

- o Length overall, 650 feet
- o Breadth molded, 70 feet

II.2. Tonnage

- o 24,000 DWT

II.3. Propulsion

- o Steam, 10000 hp

II.4. Cargo/Ballast Tanks

- o 28 independent, integral cargo tanks
- o 3 deck tanks
- o 10 double bottom ballast tanks

II.5. Cargo Pumps

- o Dedicated deepwell pumps on all integral tanks

II.6. Cargo Loading

- o Open drop, short and full loading, ship stop

II.7. Cargo Gauging Method

- o Open gauging through open ullage ports
- o Closed gauging with overflow protection available on 11 integral cargo tanks and three deck tanks

II.8. Vapor Venting System

- o Product tanks open vented through ullage ports during loading and discharging
- o B/3 vent configuration on two cargo tanks
- o 4m vent configuration on nine cargo tanks
- o Reasonable height vents on 17 cargo tanks. These vents are located at or below ullage port height with P/V valves covered with canvas bags during all transfer operations.

II.9. Tank Cleaning Method

- o Hot and cold water washing with portable Butterworth machines.
- o Number of machine drops and washing profile dependent on tank size as well as previous and next cargos.
- o Sumps stripped with steam eductors using hard piping from sump to expansion trunk combing.
- o Gas freeing using portable Coppus blowers. Number of blowers per tank dependent upon tank size and required turnaround time.

II.10. Deck Department Staffing

- o Four Mates
- o Seven A/Bs
- o Three O/Ss
- o Bosun
- o Two Pumpmen (discharge and tank washing)

III. Cargo Description and Transfer Operations

Cargo transfer operations were conducted at 9 terminals. At each terminal, these operations included either loading, discharging or a combination of discharging and loading. The cargos that were transferred as well as the transfer mode are summarized in Table I. The amount of cargo in a tank together with the tank capacity from the ullage tables was used to calculate the entries in the column labeled "% Full." In the case of cargo loading, these entries provide additional information for interpreting occupational exposures during open gauging. Table I indicates that several tanks were short-loaded. This condition can reflect either trim and load distribution considerations or economic conditions.

Transfer operations were observed and monitored at all terminals except Terminal Nos. 2, 3, 4 and 5.

All of the products in Table I, with the exception of vinyl acetate, are classified as Subchapter D products by the USCG. Vinyl acetate is a Subchapter O chemical. All of these products can be open gauged.

TABLE I. CARGO TRANSFER SUMMARY

Terminal No. 1

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
2P	Ethyl Acetate	D	96,150	32.0
2S	Cellosolve	D	92,100	30.7
3P	Butanol	D	299,400	98.0
3S	Butanol	D	299,700	98.0
7CS	Butanol	D	107,300	74.0
3CS	Cellosolve	D	116,200	40.1
4CP	Glycol	D	116,900	80.6
5CP	Isobutanol	D	142,400	98.0
5CS	Glycol	D	117,800	81.2
DT-1	Carbitol	D	47,200	98.0
DT-2	Carbitol	D	47,200	98.0
1P	Denatured Ethanol	L	151,200	56.0
1S	Cellosolve Acetate	L	124,600	46.1
2P	Isopropanol	L	269,800	89.9
2S	Isopropanol	L	270,600	90.2
1CP	HPH Fuel	L	281,000	96.9
1CS	HPH Fuel	L	280,000	96.6
7CP	HPH Fuel	L	49,000	33.8
4CP	2 Ethyl Hexanol	L	143,000	98.0
4CS	Butyl Cellosolve	L	80,600	55.6
5CP	Monoethanolamine	L	72,400	49.9
5CS	Denatured Ethanol	L	82,600	57.0
6CS	Denatured Ethanol	L	95,600	65.9
8CP	Glycol	L	74,300	26.6
10CP	Vinyl Acetate	L	196,400	60.4
10CS	Vinyl Acetate	L	197,800	60.9
DT-3	2 Ethyl Hexoic Acid	L	44,800	95.3
3CP	n-Propyl Acetate	L	83,000	28.6
4P	n-Propanol	L	151,200	46.5
4S	Amyl Alcohol	L	149,800	46.1

Terminal No. 2

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
6CP	Xylenes	L	144,100	98.0
7CS	VMP Naphtha	L	122,900	84.8
8CS	Hexane	L	139,300	48.4

TABLE I. CARGO TRANSFER SUMMARY (Continued)

Terminal No. 3

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
2CP		L	272,100	97.5
2CS		L	269,000	93.4
9CP	Methyl Tertiary	L	286,500	98.0
9CS	Butyl Ether	L	284,600	98.0
3P		L	297,300	98.0
3S		L	297,600	98.0

Terminal No. 4

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
3CS	Ethyl Acetate	L	171,500	59.1

Terminal No. 5

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
2CP		D	270,700	97.0
2CS		D	269,100	93.4
9CP	Methyl Tertiary	D	284,700	98.0
9CS	Butyl Ether	D	284,600	98.0
3P		D	295,700	98.0
3S		D	295,800	98.0

Terminal No. 6

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
1P	Denatured Ethanol	D	150,800	55.8
1S	Cellosolve Acetate	D	124,200	46.0
2P	Isopropanol	D	268,800	89.6
2S	Isopropanol	D	269,800	89.9
4P	n-Propanol	D	149,100	45.9
4S	Amyl Alcohol	D	149,800	46.1
3CP	n-Propyl Acetate	D	84,000	29.0
3CS	Ethyl Acetate	D	170,400	58.8
4CP	2 Ethyl Hexanol	D	143,300	98.0
4CS	Butyl Cellosolve	D	80,300	55.4
5CP	Monoethanolamine	D	72,600	50.0
5CS	Denatured Ethanol	D	82,500	56.9
6CS	Denatured Ethanol	D	95,000	65.5
8CP	Glycol	D	75,100	26.1

TABLE I. CARGO TRANSFER SUMMARY (Continued)

Terminal No. 6 (Continued

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
10CP	Vinyl Acetate	D	196,800	60.6
10CS	Vinyl Acetate	D	197,600	60.8
DT-3	2 Ethyl Hexoic Acid	D	44,600	94.9
3CP	Methanol	L	74,600	25.7
6CP	Methyl Ethyl Ketone	L	143,800	98.0

Terminal No. 7

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
6CP	Xylenes	D	143,800	98.0
6CS	Methyl Ethyl Ketone	D	143,900	98.0
7CS	VMP Naphtha	D	121,400	83.7
8CS	Hexane	D	137,500	47.7

Terminal No. 8

Tank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
1P	Cellosolve	L	262,000	97.0
1S	Cellosolve	L	261,500	96.8
6CP	Cellosolve	L	97,700	67.4
2P	Glycol	L	286,300	95.4
2S	Glycol	L	287,500	98.0
4P	Glycol	L	316,300	97.3
4S	Glycol	L	317,700	97.7
3CP	Glycol	L	274,300	94.6
4CS	Glycol	L	107,800	74.3
6CS	Glycol	L	90,100	62.1
DT-3	Glycol	L	47,200	98.0
1CP	Glycol	L	215,700	74.4
1CS	Glycol	L	215,900	74.4
2CP	Denatured Ethanol	L	267,400	95.8
8CP	Denatured Ethanol	L	264,800	94.9
8CS	Denatured Ethanol	L	265,900	92.3
3CS	Butanol	L	285,800	98.0
4CP	Butanol	L	144,100	98.0
10CP	Butanol	L	321,200	98.0
10CS	Butanol	L	321,900	98.0
5CP	Carbitol	L	86,600	59.7
7CS	Carbitol	L	86,400	59.6
1CP	HPH Fuel	D	280,000	96.6
1CS	HPH Fuel	D	280,600	96.8
7CP	HPH Fuel	D	49,000	33.8
3CP	Methanol	D	73,900	25.5

TABLE I. CARGO TRANSFER SUMMARY (Concluded)

Terminal No. 9

'ank No.	Cargo	Transfer Code*	Quantity (gal)	% Full
2CS	Ortho Xylene	L	285,700	98.0
7CP	Ortho Xylene	L	61,400	42.3
9CP	Ortho Xylene	L	282,700	97.8
9CS	Ortho Xylene	L	283,600	98.0
3P	Ortho Xylene	L	297,000	98.0
3S	Ortho Xylene	L	297,000	98.0

'Transfer Code: L = Load, D = Discharge

. Sampling Strategy and Sample Analysis

Occupational exposures to cargo vapors during open tank gauging, nk washing and tank entry were emphasized on this voyage. The products at were selected for exposure monitoring are summarized in Table II. ese products met of the following criteria.

- o The product has an established NIOSH sampling and analysis method.
- o The product has an equivalent sampling and analysis method that is either published in the open literature or has been independently developed by private industry.
- o The product has an ACGIH Threshold Limit Value.
- o The product is a mixture that contains discrete compounds of interest, and these compounds satisfy the first three criteria.
- o The product has the potential for generating measurable airborne concentrations.

rge (400/200) and small (100/50) charcoal tubes and passive dosimeters re used for the majority of the sample collection. Special purpose bes were used for vinyl acetate. All samples were analyzed by an AIHA credited laboratory. Desorption efficiencies were determined for each mbination of chemical constituent and sorptive medium for which the anate was detectable on the sample tube. These efficiencies reflect two plicate determinations at two loading levels. Desorption efficiency inrmation is summarized in Table III.

AD-A157 308 A CREW EXPOSURE STUDY PHASE II VOLUME 2 AT SEA PART B 4/5
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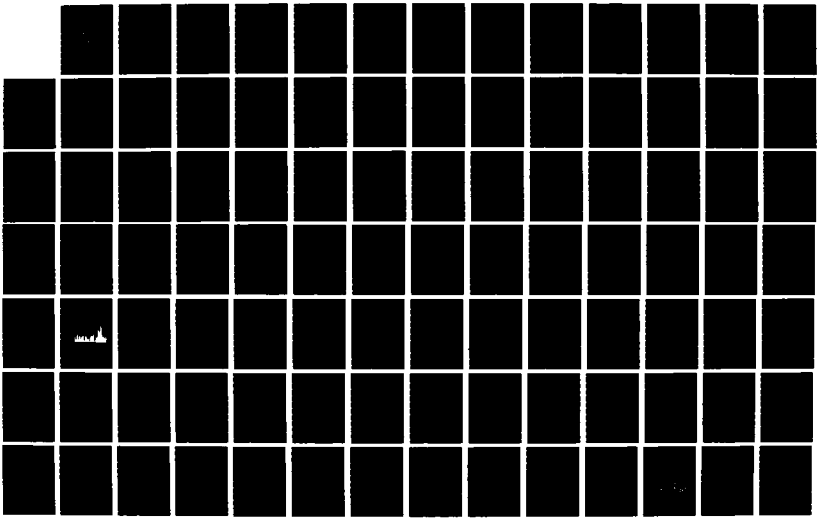
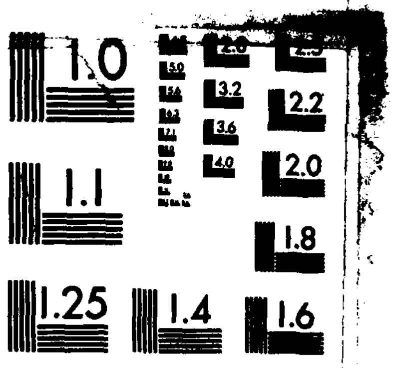




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

All charcoal tube samples were collected at a nominal flow rate of 0.2 L/min. Dosimetry pumps were calibrated before and after use. Five replicate flow rate determinations were made at each calibration. All concentration calculations reflect the average of the pre- and post-test calibrations.

Table IV contains sampling rates for the passive dosimeters.

TABLE II. PRODUCTS SELECTED FOR EXPOSURE MONITORING

Chemical	NIOSH Sampling Method No.	TLV-TWA* (ppm)	TLV-STEL* (ppm)
Cellosolve Acetate	S-41	5 (skin)	--
Ethyl Acetate	S-49	400	--
n-Propyl Acetate	S-48	200	250
Methyl Ethyl Ketone	S-3	200	300
Hexane	S-90	50	--
Xylenes (o, m or p)	S-318	100	150
Methanol	+	200 (skin)	250 (skin)
Isobutanol	S-64	50	75
Butanol	S-66	50 (C-skin)	--
n-Propanol	S-62	200 (skin)	250 (skin)
Ethanol	S-56	1000	--
Isopropanol	S-65	400	500
Butyl Cellosolve	S-76	25 (skin)	75 (skin)
Vinyl Acetate	++	10	20
HPH Fuel			
o Isophorone	S-367	5 (C)	--
o Diisobutyl Ketone	S-358	25	--
o Dicyclopentadiene	**	5	--

* Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment, ACGIH, 1984-85.

**Private industry - adsorption on charcoal, desorption with CS_2 + 10% acetone V/V.

\+ Private industry - adsorption on charcoal, desorption with acetronitrile.

++American Industrial Hygiene Association Journal, Vol. 43, No. 3, 1982.

TABLE III. SUMMARY OF DESORPTION EFFICIENCIES

Compound	Small Charcoal Tube	Large Charcoal Tube	Passive Dosimeter	Special Charcoal Tube
Cellosolve Acetate	0.805	--	0.960	--
Ethyl Acetate	0.880	--	--	--
n-Propyl Acetate	0.890	0.755	0.838	--
Methyl Ethyl Ketone	0.842	0.89	--	--
Hexane	1.045	0.989	--	--
Xylenes	0.995	0.994	0.98	--
Methanol	--	0.96	--	--
Isobutanol	0.850	--	--	--
Butanol	0.859	0.836	--	--
n-Propanol	0.760	--	--	--
Ethanol	0.726	--	--	--
Isopropyl Alcohol	0.880	--	0.466	--
Butyl Cellosolve	0.936	--	--	--
Vinyl Acetate	--	--	--	0.985
HPH Fuel				
o Isophorone	0.876	0.838	--	--
o Diisobutyl Ketone	*	*	--	--
o Dicyclopentadiene	0.938	0.936	--	--

* Desorption study deleted as analytes not detectible in personal samples

TABLE IV. PASSIVE DOSIMETER SAMPLING RATES

Compound	Sampling Rate (cc/min)*
Isopropyl Alcohol	26.9
Cellosolve Acetate	22.2
n-Propyl Acetate	28.0
Isobutanol	32.1
Butanol	31.4
Ethanol	37.5
Butyl Cellosolve	24.8
Isophorone	21.9
Diisobutyl Ketone	20.6
Dicyclopentadiene	41.6**
Xylenes	27.4
n-Propyl Alcohol	35.0

* DuPont GBB badge or GAA badge with one cover off. Sampling rate equals twice value shown for GAA badge with two covers off. All values are manufacturer's data except as noted.

** Sampling rate not available from badge manufacturer for this compound. Value shown is for cyclopentadiene.

Based on the analytical chemistry results, vapor concentrations were calculated by the methods that are shown below.

- <u>Adsorbent Tubes</u>

$$C\ (\text{ppm}) = \frac{W_c}{\eta Qt}\ \frac{24.45}{MW}\ \left(\frac{T + 263}{298} \cdot \frac{760}{P}\right)$$

where

W_c = cumulative weight of analyte on the tube corrected for blank, μg

= desorption efficiency as a decimal

Q = sampling flow rate, LPM

T = sampling temperature, °C

p = sampling barometric pressure, mm Hg

- <u>Passive Dosimeters</u>

$$C\ (\text{ppm}) = \left(\frac{W_{CF} + 2.2\ W_{CB}}{\eta(SR)\ T}\right)\left(\frac{24.45}{MW}\quad \frac{T + 273}{298} \cdot \frac{760}{P}\right)$$

where

W_{cf} = weight of analyte on exposed front strip corrected for blank, ng

W_{CB} = weight of analyte on backup strip corrected for blank, ng

SR = passive sampling rate, cm^3/min.

Other quantities are as defined for the adsorbent tubes. The pressure correction was not applied as all samples were collected at sea level conditions.

The resulting concentration data are presented in subsequent sections of this report that deal with specific operations. A total of nearly 90 samples were collected during the voyage. There was roughly an equal distribution of these samples between tank washing, tank entry and open gauging. For completeness, the USCG CHRIS code abbreviations for the chemicals of interest are presented in Table V.

TABLE V. U. S. COAST GUARD CHRIS CODE ABBREVIATIONS

Chemical	CHRIS Code
Cellosolve Acetate	EGE
Ethyl Acetate	ETA
n-Propyl Acetate	PAT
Methyl Ethyl Ketone	MEK
n-Hexane	HXA
Xylenes (o,m,p)	XLO,XLM,XLP
Methanol	MAL
Isobutanol	IAL
n-Butanol	BAN
n-Propanol	PAL
Ethanol	EAL
Isopropyl Alcohol	IPA
Butyl Cellosolve	EGM
Vinyl Acetate	VAM
Isophorone	IPH
Diisobutyl Ketone	DIK
Dicyclopentadiene	DPT

V. Tank Washing

Tank washing and ventilating are the first two steps in preparing a tank for back loading of the next cargo. On this voyage, cargo tanks were washed and ventilated both at-sea between consecutive terminals and at terminal facilities where rapid tank turnaround was needed to meet the vessel's loading plan.

Sixteen tanks were monitored during washing. Table VI identifies the products that had been carried in each of these tanks as well as the details of the in-tank washing operation. Portable Butterworth machines and portable Coppus blowers were used to wash and ventilate the tanks. In all cases, a single blower was used on each tank. A second blower was subsequently added to both 1CP and 1CS.

A more comprehensive washing procedure was used on the HPH Fuel tanks, 7CP, 1CP and 1CS.

Tank 7CP

1. 30-minute cold wash, 1 washing machine, 15 minutes each at 10 and 20 feet

2. 30-minute cold wash with surfactant at 15 foot depth, recirculate through loading drop and pump

3. Pump slops ashore

4. 45-minute hot wash, 1 washing machine, 15 minutes each at 10, 20 and 35 feet

TABLE VI. SUMMARY OF TANK WASHING DATA

Tank No.	Previous Contents	Water	No. Washing Machines	Drop Depths, Ft	Time/Depth, Min	Total Wash Time, Min
3CP	n-Propyl Acetate	Hot	2	10,20,30	15	45
6CS	Ethanol	Hot	1	10,20,30	10	30
4P	n-Propyl Alcohol	Hot	5(3+2)	10,20,30	10	60
10CP,10CS	Vinyl Acetate	Cold (Hot)	3	10(10,20,30)	15(15)	60
9CS	Wash Slops 3CP,6CS	Hot with Surfactant	1	10,20,30	15	45
2P,2S	Isopropyl Alcohol	Hot	2	10,20,30	10	30
3CS	Ethyl Acetate	Hot	2	10,20,30	10	30
8CS	Hexane	Hot	2	10,20,30	10	30
6CS	Methyl Ethyl Ketone	Hot	1	10,20,30	10	30
6CP	Xylene	Hot	1	10,20,30	10	30

1CP and 1CS

1. 30-minute cold wash, 3 washing machines, 10 minutes each at 10, 20 and 30 feet

2. Let slops soak on tank bottom for 15 minutes

3. 30-minute cold wash with surfactant at 15 foot depth, recirculate through loading drop and pump

4. Pump slops ashore

5. 45-minute hot wash, 3 washing machines, 15 minutes each at 10, 20 and 35 feet.

Washing of the HPH Fuel tanks was conducted in two phases. Phase 1 included the complete washing procedure on 7CP and the first two steps in the procedure for 1CP and 1CS. The final three steps in the 1CP and 1CS procedure constituted Phase 2.

The number of crew members that were involved in the tank washing was dependent on the number of drops (washing machines) per tank and the number of tanks that were being washed simultaneously. For example, seven crew members were involved in the simultaneous washing of 1CP and 1CS while 4P required four crew members. The washing crew consisted of one or two Pumpmen, the Bosun and a complement of A/Bs and O/Ss.

The Pumpman's duty was to periodically discharge the wash residues from the tank to either a cargo tank that was designated as a slop tank, to shore or to the drip pan through an open manifold. The A/Bs and O/Ss manually lowered the washing hoses and machines into the tank at the times indicated in the washing plan. They also removed the machines at the conclusion of washing. The Bosun functioned in a supervisory capacity but also assisted with pump operation and hose manipulation as needed.

The odor of product vapor was more pronounced at the beginning of a tank washing when the machines were at the highest elevation in the tank. Generally, odor levels declined as the machines were lowered further into the tank and the residues were pumped from the tank.

Toward the end of the washing procedure, the main cargo pump was used to strip as much liquid residue as possible from the tank bottom and sump. In this operation, the status of the discharge pump must be carefully monitored to avoid loss of suction head and pump cavitation. The pump discharge pressure gage was monitored for incipient loss of pressure head, and the pump was either shut down or the discharge valve was further closed to increase discharge pressure. Discharge of wash residue was visually verified by opening a bypass spigot on the pump discharge line. A reduced flow from the spigot indicated the approach of suction loss; the pump was then shut down. Opening of the bypass spigot resulted in discharge of wash residues onto the deck.

At the conclusion of a given washing operation, the tank dome was fully opened, the inside surface of the expansion trunk was rinsed with fresh water, the hard piped sump eductor was hooked up, the blower(s) was turned on and the washing crew moved to the next series of tanks to be washed.

On each tank, the discharge pump station was located next to the expansion trunk. The normal procedure was to crack the dome on the expansion trunk for vapor release during washing. Consequently, the Pumpman was consistently selected for occupational exposure monitoring because his primary function was to control pump operation. Other crew members that manipulated to washing hoses were selectively monitored for vapor exposure as was the Bosun.

The occupational exposure monitoring results for tank washing are presented in Table VII.

TABLE VII. OCCUPATIONAL EXPOSURES DURING TANK WASHING

Tank No.	Sample No.	Q(Lpm)	t(min)	T(°C)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
3CP,6CS	SC-22	0.196	56	21.4	SC	n-Propyl Acetate	244	5.9	Bosun
						Ethanol	ND	ND	
	SC-31	0.193	56	21.4	SC	n-Propyl Acetate	110	2.7	A/B-5
						Ethanol	ND	ND	
	SC-24	0.204	56	21.4	SC	n-Propyl Acetate	125	2.9	A/B-1
						Ethanol	ND	ND	
	62077	--	28	21.4	GAA-2	n-Propyl Acetate	164	29.5	Pumpman-1
	SC-28	0.204	56	21.4	SC	n-Propyl Acetate	376	8.7	A/B-3
						Ethanol	ND	ND	
4P	SC-23	0.202	53	21.2	SC	n-Propyl Alcohol	17	0.8	A/B-4
	SC-33	0.200	52	21.2	SC	n-Propyl Alcohol	37	1.9	A/B-1
	SC-38	0.197	78	21.2	SC	n-Propyl Alcohol	35	1.2	Bosun
	SC-26	0.200	72	21.2	SC	n-Propyl Alcohol	78	2.9	Pumpman-2
10CP,10CS	V5	0.0966	61	28.1	XLC	Vinyl Acetate	1400	69.2	Pumpman-1
	V1	0.0950	46	28.1	XLC	Vinyl Acetate	940	62.6	AB-2
2P,2S	SC-39	0.202	34	28.7	SC	Isopropyl Alcohol	ND	ND	A/B-4
	SC-55	0.200	30	28.7	SC	Isopropyl Alcohol	ND	ND	Pumpman-1
3CS	SC-54	0.200	36	29.2	SC	Ethyl Acetate	838	37.2	Pumpman-1
9CS	VCC-113	0.200	22	28.1	LC	n-Propyl Acetate	40	2.9	Pumpman-1
						Ethanol	ND	ND	
3CP	06-P9	0.202	24	25.9	LC	Methanol	693	113.9	A/B-6
	CG2-108	0.202	12	25.9	LC	Methanol	224	73.7	Pumpman-2
6CP,6CS, 8CS	SC-67	0.198	62	28.7	SC	Hexane	1270	28.4	SwRI
						Methyl Ethyl Ketone	10	0.3	
						Xylene	358	6.8	
8CS,6CS	SC-12	0-200	39	28.7	SC	Hexane	9055	319.1	Pumpman-1
						Methyl Ethyl Ketone	ND	ND	
	CG2-106	0.200	23	28.7	LC	Hexane	1650	104.2	A/B-3
						Methyl Ethyl Ketone	ND	ND	

TABLE VII. OCCUPATIONAL EXPOSURES DURING TANK WASHING (Concluded)

Tank No.	Sample No.	Q(Lpm)	Δt(min)	T(°C)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
8CS,6CS (cont)	CG2-105	0.202	22	28.7	LC	Hexane	573	37.4	O/S-2
						Methyl Ethyl Ketone	ND	ND	
6CP	SC-65	0.200	25	28.7	SC	Xylene	1690	79.2	A/B-6 on pump
						Hexane	128	7.0	
						Methyl Ethyl Ketone	ND	ND	
	CG2-110	0.204	44	28.7	LC	Xylene	ND	ND	A/B-3
						Hexane	ND	ND	
						Methyl Ethyl Ketone	ND	ND	
	BF-8	0.202	98	28.7	LC	Xylene	1340	15.9	O/S-2
						Hexane	330	4.8	
						Methyl Ethyl Ketone	32	0.6	
7CP + Φ1 (1CP,1CS)	DD-19	0.200	165	29.2	LC	Isophorone	ND	ND	Pumpman-2
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	ND	ND	
	CG2-109	0.202	150	29.2	LC	Isophorone	ND	ND	O/S-1
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	ND	ND	
Φ2(1CP,1CS)	BF-25	0.202	90	30.9	LC	Isophorone	ND	ND	Bosun
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	ND	ND	
	BF-24	0.202	112	30.9	LC	Isophorone	ND	ND	Pumpman-3 (Replaced Pumpman-1)
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	ND	ND	

*SORBENT KEY
SC = Small Charcoal (100/50)
LC = Large Charcoal (400/200)
XLC = Special Purpose VAM Tube
GAA-2 = Passive Dosimeter, 2 Covers Removed

+ND = Not Detectable

Several tanks were washed simultaneously.

- o 3CP - n-Propyl acetate, 6CS - Ethanol
- o 10CP, 10CS - Vinyl acetate
- o 2P, 2S - Isopropyl alcohol
- o 8CS - Hexane, 6CS - Methyl ethyl ketone
- o 7CP, 1CS, 1CP - HPH Fuel

In the case of 6CP, which had carried xylene, other exposure chemicals were included in the analysis because of the proximity of 8CS and 6CS, which were being ventilated concurrently. The three compounds listed for 7CP, 1CP and 1CS were chemicals of interest in the HPH Fuel.

The use of personal protective equipment varied between members of the washing crew. Chemical goggles were available for splash protection when washing hoses were lowered in the tank. Some crew members wore the goggles properly, others wore the goggles on top of their hats and some individuals did not carry goggles. On a given tank, the level of goggle usage varied among the washing crew. Similar variability existed in glove usage for dermal protection. Some crew members wore rubber gloves while others had rubber gloves but did not use them. Other crew members either did not wear gloves or wore conventional work gloves.

The expansion trunk and pump for Tank 9CS was located in an area of the deck that was highly shielded from the ambient wind. The Pumpman anticipated the potential for vapor accumulation and wore an organic vapor cartridge respirator.

On one occasion, a member of the washing crew collected some wash residues from the pump bypass spigot in an unprotected hand. The purpose of this practice was to smell the wash water for product odor; lack of odor was an indication of tank cleanliness.

VI. Tank Entry

Following washing and ventilating, crew members entered cargo tanks as the final step in preparing the tanks for a change in cargo grade. Nineteen separate tanks were monitored during entry. These entries, which involved 15 products, resulted in 29 occupational exposure samples. Fourteen of these products were simple chemicals; one product, HPH Fuel, was a complex mixture of three hydrocarbon processing streams. All of the products were classified under Subchapter D with the exception of Vinyl Acetate, which is a Subchapter O chemical.

Each tank entry usually involved one or two crew members. The work to be conducted included sweeping of debris and damp mopping of residual liquid on the tank bottom and vacuuming the pump sump to remove wash slops. The equipment that was used to accomplish these tasks included buckets, mop, dust pan, broom and vacuum eductor hose.

Observations regarding the tank entry procedure are as follows.

- All tank entries were authorized without testing the atmospheres for oxygen, combustible gas or toxicity levels.

- During entry, ventilation was provided to eight of the 19 tanks.

- Tank entries were performed without respiratory protection (SCBA, EEBA or air-purifying).

- With one exception, a safety watch was present at each open expansion trunk during tank entry.

- Protective equipment such as chemical goggles and chemical-resistant "rubber" boots were not used. Cloth work gloves were used by the crew members with the exception of one A/B who used "rubber" gloves.

and the use of permanently-installed, in-tank stripper pumps to minimize either the need for tank entry or the exposure levels during entry following washing and ventilation.

Occupational exposure monitoring was supplemented by area monitoring and the use of direct reading instruments for measuring instantaneous breathing zone concentrations of total hydrocarbon vapor.

Additionally, noise dosimetry data were collected during many phases of the voyage to characterize noise levels encountered during various activities possibly unique to this ship.

The data in this Voyage Report were collected on a new tanker that was roughly one year old. The vessel was still in a transition with respect to installation of final, permanent equipment, systems and procedures. Therefore, certain operations or situations that were observed could be considered temporary or non-routine in nature.

Certain work practice procedures had been developed by the company. But because of the changing conditions described above, the final work environment had not been fully surveyed; therefore, some of the procedures could not be fully implemented. For example, a hearing conservation program had been developed, and implementation is planned after the working environment stabilizes. Consequently, the noise data that are presented in this report were collected primarily to characterize noise levels as opposed to evaluation of exposures relative to a selected guideline. A tank entry procedure and permit system had been developed by the company.

I. Trip Overview and Objectives

The primary objective of this voyage was to monitor occupational exposures to cargo vapors during Deck Department operations aboard a state-of-the-art chemical tanker. The voyage lasted 14 days. The project team boarded the vessel at the initial discharge terminal. The remainder of the voyage included:

- four additional discharge terminals,
- a back loading of a pure chemical at one of the discharge terminals,
- the ballast voyage, during which tank processing and entry were performed,
- a stop at a repair facility, Terminal 6, for installation of equipment,
- discharging of a pure chemical onto a barge while at the repair facility, and
- loading at a seventh terminal.

Exposure monitoring began just after the start of discharge at the first terminal and continued through a major portion of the loading at the seventh terminal. This effort reflected operations that are unique to vessels equipped with certain cargo handling systems that have been installed to minimize exposures. Examples of such systems include closed cargo transfer during loading and discharge, high velocity vapor venting during loading, closed gauging up to top off, use of a portable restricted gauge device at top off, smooth tank interiors, slopes tank bottoms to stripper sumps, higher than conventional ventilation system capacities,

VOYAGE 6 REPORT OUTLINE

I. Trip Overview and Objectives

II. Vessel Description

III. Cargo Description

IV. Sampling and Sample Analysis

V. Product Discharging

VI. Tank Processing

VII. Tank Entries

VIII. Product Loading

IX. Miscellaneous Activities/Samples

APPENDIX F

VOYAGE REPORT - VOYAGE 6

TABLE IX. OCCUPATIONAL EXPOSURES DURING OPEN TANK GAUGING (Concluded)
(PERIODIC AND TOP OFF)

Tank No.	Sample No.	Q(Lpm)	t(min)	T(°C)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel	Comment
10CP	SC-16	0.205	17	27.0	SC	Butanol	47	5.2	3M-2	Tank Top Off
4CP	DM-22	0.200	31	27.0	SC	Butanol	230	14.3	AB-2	Standby Cargo Valve and Assist 3M
4CP	DD-18	0.204	6	27.0	LC	Butanol	560	181.7	3M-2	Tank Top Off
9CS	SC-45	0.193	142	27.0	SC	Ortho Xylene	1820	15.5	AB-5	Periodic Gauge
9CP	SC-77	0.222	138	27.0	SC	Ortho Xylene	297	2.2	AB-7	Periodic Gauge
9CP,9CS	SC-19	0.193	110	27.0	SC	Ortho Xylene	595	6.5	3M-2	Periodic Gauge
9CS	SB-211	0.201	12	27.0	LC	Ortho Xylene	1240	119.9	3M-2	Tank Top Off
9CP	BF-9	0.191	4	27.0	LC	Ortho Xylene	30	9.2	3M-2	Tank Top Off
7CP,2CS	62065	--	104	28.7	GBB	Ortho Xylene	1330	111.0	2M	Top Off 7CP then 2CS
2CS	SB-210	0.191	29	28.7	LC	Ortho Xylene	2750	116.4	2M	Tank Top Off, Waltzing Sampler
3P,3S	SC-78	0.202	146	30.3	SC	Ortho Xylene	594	4.7	3M-1	Periodic Gauge
3P,3S	SC-79	0.211	15	32.6	SC	Ortho Xylene	565	42.4	3M-2	Tank Top Off

*SORBENT KEY
SC = Small Charcoal Tube (100/50)
LC = Large Charcoal Tube (400/200)
GAA-2 = Passive Dosimeter, Two Covers Off
GBB = Passive Dosimeter with Backup Section

+ND = Not Detectable

TABLE IX. OCCUPATIONAL EXPOSURES DURING OPEN TANK GAUGING
(PERIODIC AND TOP OFF)

Tank No.	Sample No.	Q(Lpm)	t(min)	T(°C)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel	Comment
1S	48955	--	7	36.4	GAA-2	Cellosolve Acetate	20	12.9	2M	Tank Top Off
6CS	62079	--	26	36.4	GAA-2	Ethanol	ND	ND	2M	Tank Top Off
10CP,10CS	V9	0.0966	184	29.2	XLC	Vinyl Acetate	1300	21.4	3M-1	Periodic Gauging
10CP,10CS	V2	0.0985	12	27.0	XLC	Vinyl Acetate	2	0.5	2M	Tank Top Off, Waltzing Sampler
10CS	V3	0.0966	73	28.1	XLC	Vinyl Acetate	12000	495.7	--	Area Sample Above Ullage Port
2P,2S	62791	--	164	29.2	GBB	Isopropyl Alcohol	561	112.6	3M-1	Periodic Gauge
2P,2S	63779	--	115	28.1	GBB	Isopropyl Alcohol	1320	376.4	2M	Periodic Gauge
2S	SC-21	0.194	62	29.2	SC	Isopropyl Alcohol	16850	656.8	3M-2	Periodic Gauge
2P	SC-25	0.196	73	29.2	SC	Isopropyl Alcohol	6754	221.3	A/B-2	Periodic Gauge
2P,2S	SC-18	0.204	9	29.8	SC	Isopropyl Alcohol	933	238.7	3M-2	Tank Top Off
4P	62078	--	67	35.3	GAA-2	n-Propyl Alcohol	ND	ND	2M	Periodic Gauge and Top Off
1CP,1CS	48954	--	26	29.2	GBB	HPH Fuel	ND	ND	3M-1	Periodic Gauge and Top Off
6CS	SC-40	0.204	159	17.6	SC	Methyl Ethyl Ketone	117	1.4	3M-2	Periodic Gauge
	SC-29	0.193	57	17.6	SC	Methyl Ethyl Ketone	1400	50.0	3M-2	Tank Top Off
10CP,10CS, 3CS,4CP	63780	--	126	29.2	GBB	Butanol	ND	ND	2-M	Periodic Gauge
3CS,4CP	SC-70	0.202	96	28.1	SC	Butanol	1810	36.2	3M-1	Periodic Gauge
3CS	SC-73	0.205	10	28.1	SC	Butanol	70	13.2	C/M	Tank Top Off
10CP,10CS	SC-76	0.205	81	27.0	SC	Butanol	731	17.0	3M-2	Periodic Gauge
10CS	X-31	0.200	22	27.0	SC	Butanol	929	81.6	3M-2	Tank Top Off
10CP	DM-42	0.200	7	27.0	SC	Butanol	10	2.8	AB-2	Open Valve on 10CP during 10CS Top Off

requested by the purchaser. The final seven minutes included continuous gauging of 6CS as the incremental quantity of MEK was loading into the tank. On the basis of 17 minutes of actual gauging time, a maximum estimated exposure concentration of 167.6 ppm MEK was calculated.

Open tank gauging from deck level produces the maximum exposure potential. One of the Third Mates (designated 3M-2 in the subsequent tables) routinely used an organic vapor cartridge respirator when topping off tanks as well as during the latter half of a loading when he was conducting periodic gauging. Other Mates and A/Bs on cargo transfer watch did not use respiratory protection.

Generally, two crew members were involved in a tank top off. The Mate performed the ullage gauging, and an A/B manned the cargo valve near the expansion trunk. If the same cargo was being delivered to two tanks simultaneously, the A/B would open the cargo drop on the tank that was not being topped so as to divert maximum flow away from the tank being topped. One Third Mate (3M-2) dismissed the A/B crew as soon as possible at top off time so as to minimize their exposure.

Table IX summarizes the results of the occupational exposure samples that were collected during open tank gauging. The table contains several natural groupings of samples. The second, fourth and fifth groups each deal with the loading of a large quantity of a single product; and, in general, the samples within each of these three groups are arranged sequentially in time from the beginning of product loading through top off of the final tank.

The term "waltzing sampler" appears twice in Table IX. In both cases, the sampling equipment was held in the 2M's breathing zone by a member of the SwRI project team. As such, these two samples approximate the 2M's exposure, but correctly they are not true occupational exposure samples.

Sample No. SC-29 was collected during top off of tank 6CS which held MEK. The actual top off consisted of a 10-minute interval and a seven-minute interval separated by 40 minutes of non-contact time. After the first 10-minute period, cargo transfer was terminated at the predetermined stop ullage. The succeeding 40 minutes were spent in the deck house determining if the tank could accommodate an additional quantity of MEK as

- the quantity of cargo to be loaded in relationship to the tank capacity and

- the use of personal protective equipment.

The predominant gauging technique consisted of viewing through the open ullage port to visually verify contact of the tape bob with the liquid surface. This technique was applied while standing on the deck next to the expansion trunk with the breathing zone within one to two feet of the ullage port opening. Generally, there was a tendency to stand upwind or crosswind, if possible. Using this method, the potential for vapor exposure increases throughout loading and is maximum at tank top off. The Second Mate occasionally used an alternate technique of standing on the expansion trunk dome. This method effectively increased the separation distance between the ullage port and breathing zone, which permitted vapors to be diluted and dispersed by local wind currents. The Second Mate conscientiously held his breath when viewing into the tank from either on top of the dome or from deck level. The Chief Mate demonstrated a third gauging technique for topping off Tank 3CS. Contact of the gauging bob with the liquid surface was determined by "feel". His gauging position was some distance away from the expansion trunk with the breathing zone out the main body of the vapor plume. Because 3CS was to be loaded to 98 percent of capacity, he could also see the liquid surface contact the tank access ladder from his gauging position.

The amount of cargo to be loaded into a tank correlates with the exposure potential. Section III of this report indicates that several tanks were short-loaded, i.e. the quantity loaded was significantly less than the tank capacity. During periodic gauging and top off of a short-loaded tank, vapor discharge concentrations are less than when the tank is to be fully loaded.

VII. Open Tank Gauging

The quantity or volume of a product that was to be loaded into a given tank was established at a pre-loading conference. The ullage tables for a given tank were then used to define the final or "stop ullage" that corresponded to the predetermined product volume. While a given tank was being loaded, it was periodically gauged to determine the current ullage, the loading rate and a projected time to completion of product transfer. During the initial stages of loading, the frequency of periodic gauging was guided by the tank size, the loading rate and the "stop ullage." At an ullage slightly greater than the final ullage, the periodic gauging phase terminated, and the top off phase was initiated. This top off phase was relatively short and was characterized by very frequent and sometimes continuous gauging until the "stop ullage" was reached. In all cases the loading of a given product was terminated by the ship, i.e. ship stop.

The cargo transfer officer on watch was responsible for all gauging. In all cases, the top off phase was performed by the Mate on watch. The periodic gauging activity was performed either by the Mate or it was delegated to an A/B under supervision of the Mate.

In accordance with USCG cargo classification criteria, open gauging of ullage was permitted for all cargos that were associated with this voyage. The majority of the periodic gauging and all of the top off gauging was performed through open ullage ports using a Lufkin tape. On occasion, the closed gauging system in the ship's office was used for tanks with long loading times.

In addition to the cargo properties, the potential for occupational exposure to product vapors is a combined function of

- o the gauging technique,

TABLE VIII. OCCUPATIONAL EXPOSURES DURING TANK ENTRY (Concluded)

Tank No.	Sample No.	Q(Lpm)	Δt(min)	T(°C)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
ICP-2 (cont)	BF-26	0.204	52	28.7	LC	Isophorone	15	0.3	Bosun
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	160	3.0	
ICS	CG2-103	0.200	37	28.1	LC	Isophorone	15	0.4	A/B-6
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	120	3.2	
	CG2-102	0.204	25	28.1	LC	Isophorone	10	0.4	A/B-3
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	120	4.7	

*SORBENT KEY
SC = Small Charcoal (100/50)
LC = Large Charcoal (400/200)
XLC = Special Purpose VAM Tube

+ND = Not Detectable

TABLE VIII. OCCUPATIONAL EXPOSURES DURING TANK ENTRY

Tank No.	Sample No.	Q(Lpm)	t(min)	T(°C)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
5CP	SC-35	0.194	10	33.7	SC	Isobutanol	81	16.7	A/B-3
	SC-36	0.196	10	33.7	SC	Isobutanol	124	25.3	A/B-2
2P	SC-37	0.196	9	37.0	SC	Ethyl Acetate	25	4.6	SwRI
3S	SC-30	0.204	10	35.3	SC	Butanol	510	99.3	A/B-2
3CP	SC-34	0.196	22	29.8	SC	n-Propyl Acetate	94	5.9	A/B-3
6CS	SC-32	0.204	13	29.8	SC	Ethanol	46	12.9	A/B-5
1S	SC-51	0.202	14	32.6	SC	Cellosolve Acetate	1940	161.8	A/B-5
1P	SC-27	0.200	14	32.6	SC	Ethanol	872	233.8	A/B-7
10CS	V-15	0.095	9	28.1	XLC	Vinyl Acetate	7	2.4	A/B-3
10CP	V-4	0.095	13	28.1	XLC	Vinyl Acetate	7	1.6	A/B-2
	V-6	0.0966	11	28.1	XLC	Vinyl Acetate	7	1.9	A/B-3
4P	SC-56	0.200	26	29.8	SC	n-Propyl Alcohol	99	10.4	A/B-2
	SC-58	0.202	19	29.8	SC	n-Propyl Alcohol	85	12.0	SwRI
2S	MC-27	0.197	11	29.2	SC	Isopropyl Alcohol	281	60.8	A/B-1
	SC-57	0.200	8	29.2	SC	Isopropyl Alcohol	244	71.5	A/B-4
2P	SC-59	0.200	11	29.8	SC	Isopropyl Alcohol	15	3.2	A/B-3
4CS	SC-52	0.197	15	29.8	SC	Butyl Cellosolve	110	8.4	A/B-1
6CS	SC-60	0.198	28	28.7	SC	Methyl Ethyl Ketone	299	22.0	A/B-2
8CS	SC-63	0.205	23	28.7	SC	Hexane	1470	85.7	A/B-3
	SC-62	0.200	25	28.7	SC	Hexane	2850	156.7	A/B-4
6CP	SC-69	0.200	24	28.7	SC	Xylene	713	34.8	A/B-3
3CP	CGS-104	0.202	19	29.2	LC	Methanol	133	27.9	A/B-7
1CP,1CS	SC-61	0.200	5	28.7	SC	Isophorone	ND	ND	Bosun
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	8	1.6	
1CP-1	DM-43	0.205	24	28.7	SC	Isophorone	5	0.2	A/B-3
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	46	1.9	
	SC-66	0.200	22	28.7	SC	Isophorone	5	0.2	Bosun
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	48	2.2	
1CP-2	DW-13	0.200	37	28.7	LC	Isophorone	ND	ND	A/B-3
						Diisobutyl Ketone	ND	ND	
						Dicyclopentadiene	88	2.4	

Information concerning the bulk composition of HPH Fuel indicated that isophorone, diisobutyl ketone and dicyclopentadiene were the chemical components of interest for occupational exposures.

Table VIII summarizes the results of the occupational exposures that were monitored during tank entry. Exposure monitoring opportunities did not materialize for every crew member that entered a tank because

- o it was not uncommon for one crew member to have entered a tank prior to the time that a second crew member entered the same tank to perform the directed cleaning,
- o some crew members entered tanks apparently on their own initiative, and
- o some cleaning entries were performed out of sequence while other planned washing and entry activities were in progress.

- Material Safety Data Sheets (MSDS) were available on the ship for all products except HPH Fuel.

- A Confined Space Entry Procedure and Entry Permit System had been initiated by the ship operator but was not followed.

The objective of the washing, ventilating and manual cleaning operations was to generate a dry tank which was free of the odor of the last product. These two conditions were necessary for the tanks to be approved for product loading by the independent cargo surveyors.

On two of the tanks, 1CP and 1CS, these conditions could not be achieved without extensive in-tank mucking. Product odor remained after washing, ventilating and injecting of an odor masking liquid through the Coppus blowers. These two uncoated tanks carried HPH Fuel. Rust and scale sludges on the tank bottom contained residues of product and wash water. The sludge served as a source of vapor regeneration. Two hours prior to manual cleaning of either tank, an A/B entered and quickly exited 1CP as the vapors were too strong. The tanks were ventilated for an additional 105 minutes. At the end of that time, the Bosun briefly entered both tanks and indicated that additional ventilation was needed. A second blower was installed on each tank. Seventeen minutes later 1CP was entered for cleaning.

Tank 1CP was mucked first. The cleaning equipment was the same as was used on all tank entries with the addition of an air operated winch that was used to hoist buckets of sludge to the deck. Initially, the Bosun and an A/B entered the tank for a period of 22 and 24 minutes, respectively. During this time, roughly 19 2-1/2 gallon buckets of sludge were removed. A short time after egress, the same two crew members reentered 1CP for an additional 37 and 25 minutes, respectively. On the second entry, 14 buckets of sludge were removed from the tank. The Chief Mate also entered the tank twice to assist with the mucking. Cleaning of 1CS followed the same procedure with seven buckets of sludge being removed from the tank.

II. Vessel Description

II.1. Dimensions

- o Length overall, 630 feet
- o Breadth, 110 feet

II.2. Tonnage

- o 42000 DWT

II.3. Cargo/Ballast Tanks

- o 43 cargo tanks
- o 4 segregated ballast wing tanks
- o 10 double bottom ballast compartments
- o 1 forepeak ballast tank
- o 3 gale ballast/cargo tanks

II.4. Cargo/Ballast Pumps

- o 43 independent deepwell cargo pumps controlled at the pump and in the Cargo Control Room.
- o 28 permanently installed, compressed air sump stripper pumps.
- o Portable stripper pumps for sump stripping on tanks without permanent strippers.
- o 2 ballast pumps.
- o Ballast pumps and routing valves controlled remotely in Cargo Control Room.

II.5. Cargo Gauging Systems

- Two closed gauging systems on each tank, both with local and remote readout.

- Portable Restricted Gauging System on each tank.

II.6. Vapor/Gas Venting

All cargo transfer took place with ullage ports and expansion trunks dogged down. During loading, vapor venting was accomplished through elevated Pres-Vac high velocity vents. Vacuum relief valves permitted ingestion of fresh air into the tanks during discharge for those not inerted.

Bypass lines, which enabled venting to the atmosphere without going through the high velocity vents, were available for each of the tanks. These lines were opened by loosening wing nuts and opening the cap. This bypass system was used during tank ventilation to allow the ullage ports, expansion trunks, and Butterworth plates to remain dogged down.

II.7. Cargo Loading

All products were closed-loaded. Each cargo tank had a dedicated manifold flange and dedicated deck piping. For flexibility, additional deck piping and mix-masters were available to expedite cargo transfer in special situations.

II.8. Tank Cleaning Method

Thirty tanks are fitted with fixed Butterworth washing machines. The remaining tanks are washed with portable machines. Wash water flowrates for the fixed machines range from about 150 to 250 gpm. Hot or cold, fresh or salt water can be used in tank washing.

The main cargo pumps are used to discharge the majority of the wash residue to a slop tank, which also serves as a cargo tank. Slops are discharged to shore. Sumps are stripped with fixed and portable air strippers. These strippers can be powered by dehumidified air, inert gas or compressed air.

Following washing, gas freeing can be accomplished by using either the dehumidified air system, which is hard-piped to the tanks, or the conventional portable blowers or both.

II.9. Inert Gas System

The vessel was fitted with a diesel fired gas inerting system. Inert gas service is available to 14 tanks that carry products that are unaffected by the gas blanket.

II.10. Dehumidified Air System

Dehumidified air service is available to 42 tanks. It is used primarily to maintain a dry atmosphere in tanks at all times and secondarily for tank purging or gas freeing operations following tank washing. In the latter case, the use of dehumidified air expedites tank drying. This air service can also be used to drive sump stripping pumps and to blow cargo transfer lines at the end of discharge.

II.11. Deck Department Staffing

- Four Mates (CM, 2M, 3M, 3M)
- Six Able-bodied Seamen (AB)
- One or Two Ordinary Seamen (OS)
- Two Pumpmen (PM)

III. Cargo Description

A total of 24 different pure chemicals, gasolines, solvents, intermediate streams, and oils were handled on this voyage. The status of the cargo tanks upon arrival at the first discharge terminal is shown in Table III.1. Prior to leaving the third discharge terminal, MEK was backloaded into cargo tank 4CA for transport to the sixth discharge terminal. The status of the cargo tanks after the loading at the last terminal is shown in Table III.2.

TABLE III.1. STATUS OF CARGO TANKS PRIOR TO DISCHARGE AT TERMINAL 1

Tank No.	Chemical	Capacity (BBL)	Quantity* (BBL)	Percent Full
1P	Paraxylene	7495	7187	95.9
1C	Stoddard Solvent A	12539	10996	87.7
1S	Aromatic Solvent	7495	7239	96.6
2P	Stoddard Solvent B	6941	6668	96.1
2CF	Toluene	4301	4128	96.0
2CA	Empty	4301	-0-	0.0
2S	VM&P Naphtha	6941	2958	42.6
3P	Empty	3740	-0-	0.0
3C	Stoddard Solvent A	1724	1650	95.7
3S	Empty	3740	-0-	0.0
4P	Paraxylene	11581	9386	81.0
4CF	Stoddard Solvent A	2151	2056	95.6
4CA	Acetone	12476	10369	83.1
4S	Stoddard Solvent B	11581	9993	86.3
5P	Paraxylene	15525	15026	96.8
5CF	Paraxylene	8600	8243	95.8
5CA	Paraxylene	8192	7851	95.8
5S	Paraxylene	15525	15026	96.8
6P	White Oil A	7764	7536	97.1
6CF	Isoparaffinic Solvent	4748	3020	63.6
6CA	Lube Oil	4301	3941	91.6
6S	Empty	7764	-0-	0.0
7P	Process Oil B	7764	3051	39.3
7CF	Empty	4301	-0-	0.0
7CA	White Oil B	4301	3017	70.1
7S	Process Oil A	7764	4912	63.3
8P	Refinery Feed Stock	11644	7503	64.4
8CF	Bright Stock	4301	3926	91.3
8CM	Process Oil C	4301	4053	94.2
8CA	Empty	1724	-0-	0.0
8S	Refinery Feed Stock	11644	11298	97.0
9P	Ballast	--	--	--
9CF	Empty	2151	-0-	0.0
9CM	Process Oil D	8178	4937	60.4
9CA	White Oil A	8600	8251	95.9
9S	Ballast	--	--	--
10P	Refinery Feed Stock	19406	18807	96.9
10C	Refinery Feed Stock	21088	10079	47.8
10S	Refinery Feed Stock	19406	18837	97.1
11PF	Paraxylene	11626	4898	42.1
11PA	Unleaded Gas	11315	10844	95.8
11C	Unleaded Gas	25387	23932	94.3
11SF	Paraxylene	11626	11302	97.2
11SA	Unleaded Gas	11315	10898	96.3

*Net Barrels

TABLE III.2. STATUS OF CARGO TANKS AFTER LOADING AT TERMINAL 7

Tank No.	Chemical	Capacity (BBL)	Quantity* (BBL)	Percent Full
1P	Naphtha	7495	6000	80.1
1C	Stoddard Solvent B	12539	10000	79.8
1S	VM&P Naphtha	7495	6000	80.1
2P	Heptane	6941	6000	86.4
2CF	Xylene	4301	3300	76.7
2CA	Xylene	4301	3300	76.7
2S	Paraffinic Solvent	6941	6000	86.4
3P	Empty	3740	-0-	0.0
3C	Empty	1724	-0-	0.0
3S	Empty	3740	-0-	0.0
4P	Paraxylene	11581	11400	98.4
4CF	Empty	2151	-0-	0.0
4CA	Stoddard Solvent A	12476	9000	72.1
4S	Extra Unleaded Gasoline	11581	11400	98.4
5P	Paraxylene	15525	15250	98.2
5CF	Paraxylene	8600	8350	97.1
5CA	Stoddard Solvent B	8192	8000	97.7
5S	Extra Unleaded Gasoline	15525	15250	98.2
6P	White Oil A	7764	7600	97.9
6CF	Lube Oil	4748	4600	96.9
6CA	White Oil B	4301	3000	69.8
6S	Insulating Oil	7764	3000	38.6
7P	Lube Oil	7764	7600	97.9
7CF	Hydraulic Oil	4301	4200	97.7
7CA	White Oil A	4301	4200	97.7
7S	Lube Oil	7764	7600	97.9
8P	Extra Unleaded Gasoline	11644	11400	97.9
8CF	White Oil A	4301	4200	97.7
8CM	Lube Oil	4301	4200	97.7
8CA	Hydraulic Oil	1724	800	46.4
8S	Extra Unleaded Gasoline	11644	11400	97.8
9P	Ballast	--	--	--
9CF	Empty	2151	-0-	0.0
9CM	Process Oil A	8178	5000	61.1
9CA	Lube Oil	8600	6000	69.8
9S	Ballast	--	--	--
10P	Gasoline Blend Stock	19406	19000	97.9
10C	Gasoline Blend Stock	21088	20500	97.2
10S	Gasoline Blend Stock	19406	19000	97.9
11PF	Hexane	11626	3000	25.8
11PA	Gasoline Blend Stock	11315	11100	98.1
11C	Extra Unleaded Gasoline	25387	24700	97.3
11SF	Paraxylene	11626	11400	98.1
11SA	Extra Unleaded Gasoline	11315	11100	98.1

*Quantities (net barrels) as indicated in the loading plan

IV. Sampling Strategy and Sample Analysis

The bulk liquid products that were handled during this voyage are summarized in Table IV.1. Also listed in this table are the chemicals' corresponding ACGIH TLVs or company Occupational Exposure Limits (OEL).

TABLE IV.1. PRODUCTS HANDLED DURING THIS VOYAGE

Chemical	ACGIH TLV-TWA (ppm)	ACGIH TLV-STEL (ppm)	Company OEL*
Acetone	750	1000	--
Aromatic Solvent	--	--	50 ppm THC
Bright Stock	--	--	5 mg/m^3
Unleaded Gasolines	300	500	100 ppm THC, 5 ppm BNZ
Heptane	400	500	--
Hexane	50	--	--
Isoparaffinic Solvent	--	--	300 ppm THC
Lube Oil	--	--	5 mg/m^3
Methyl Ethyl Ketone	200	300	--
Paraxylene	100	150	--
Process Oil A	--	--	5 mg/m^3
Process Oil B	--	--	5 mg/m^3
Process Oil C	--	--	5 mg/m^3
Process Oil D	--	--	5 mg/m^3
Refinery Feed Stock (RFS)	--	--	100 ppm THC, 5 ppm BNZ
Stoddard Solvent A	100	200	100 ppm THC
Stoddard Solvent B	--	--	200 ppm THC
Toluene	100	150	--
VM&P Naphtha	300	400	--
White Oil A	--	--	5 mg/m^3
White Oil B	--	--	5 mg/m^3

*Occupational Exposure Limit

THC = total hydrocarbon concentration

The products selected for exposure monitoring are listed in Table IV.2. With one exception the oils, including bright stock, lube oil, process oils, and white oils, were not monitored. The decision not to generally sample for these oils was based on the fact that the company OELs were based on mists, and the potential for the presence of oil mists, under most operations, was very low. One oil mist sample, for Process Oil B, was taken during a tank entry to document that oil mists were not present.

Large (400/200) and small (100/50) charcoal tubes and passive dosimeters were used for sample collection of vapors. All charcoal tube samples were collected at a nominal flowrate of 0.2 L/min. Dosimetry pumps were calibrated before and after use. Five replicate flow rate determinations were taken during each calibration. The actual sample flowrates used in concentration calculations represent averages of the pre- and post-test calibrations.

A mixed esters of cellulose (0.8 micron pore size) filter was used on one occasion for sample collection of oil mist. This sample was collected at a nominal flowrate of 1.5 L/min. The dosimetry pump was calibrated using the method discussed above for the charcoal tube pumps.

Many of the products handled during this voyage were not pure chemicals. Therefore, it was necessary to identify the compounds of interest for analysis for each of the products. These compounds for analysis, which took into consideration the product material safety data sheet information, are summarized in Table IV.2. For the products with multiple compounds of interest, the compounds were assigned priorities of 1, highest priority, to 3, lowest priority. During the first round of analysis, only the concentrations of the highest priority compounds were quantified. As warranted, based on the results from previous analysis rounds, additional analysis rounds quantified the concentrations of the lower priority compounds.

TABLE IV.2. PRODUCTS SELECTED FOR EXPOSURE MONITORING

Product	Compounds for Analysis
Acetone	ACT
Aromatic Solvent XLO,M,P	THC
Extra Unleaded Gasoline BNZ HXA TOL XLO,M,P	THC
Heptane	HPT
Hexane	HXA
Isoparaffinic Solvent	THC
Methyl Ethyl Ketone	MEK
Paraxylene	XLP
Process Oil B	Process Oil B
Refinery Feed Stock BNZ HXA TOL XLO,M,P	THC
Stoddard Solvent A	THC
Stoddard Solvent B	THC
Toluene	TOL
VM&P Naphtha	THC

When a sample was associated with a single pure compound, the recommended NIOSH analysis method for that chemical was followed.

When there was a potential for a sample to contain a mixture of vapors from (1) pure chemicals of interest and (2) wide boiling point compounds with OELs based on total hydrocarbon, then nitrobenzene was used as the desorption solution. These samples were analyzed for total hydrocarbon concentration through xylene expressed as hexane. The remainder of the chemicals of interest on these samples were quantified using the nitrobenzene desorption solution.

Desorption efficiencies were determined for each combination of chemical constituent, sorptive medium, and desorption solution for which the analyte was detected on the sample. These efficiencies reflect two replicate determinations at two loading levels. Desorption efficiency information is summarized in Table IV.3.

Passive dosimeter sampling rates are generally not available for complex vapor mixtures from products with wide boiling point ranges. A nominal sampling rate of 30 cc/min was assumed when passive dosimeters were used under these conditions.

Based on the analytical chemistry results, vapor concentrations were calculated by the methods that are shown below.

- <u>Adsorbent Tubes</u>

$$C\ (\text{ppm}) = \frac{W_c}{\eta Q t} \cdot \frac{24.45}{MW} \left(\frac{T + 273}{298} \cdot \frac{760}{P} \right)$$

where

W_C = cumulative weight of analyte on the tube corrected for blank, μg
η = desorption efficiency as a decimal
Q = sampling flow rate, LPM
T = sampling temperature, °C
MW = molecular weight
P = sampling barometric pressure, mm Hg
t = sampling time, min.

TABLE IV.3. SUMMARY OF DESORPTION EFFICIENCIES

Desorption with Nitrobenzene			
Chemical	SC*	LC*	GBB*
Acetone	0.795		
Benzene	1.023	1.044	
Heptane		0.980	
Hexane	.96	1.04	1.010
Toluene	1.067	1.000	
Xylene (p)	0.994	1.015	

Desorption with Carbon Disulfide	
Chemical	SC
Hexane	1.045
Methyl Ethyl Ketone	0.842
Xylene (p)	0.995

* GBB - passive badge dosimeter
SC - small charcoal tube
LC - large charcoal tube

o <u>Passive Dosimeters</u>

$$C\ (\text{ppm}) = \left(\frac{W_{CF} + 2.2\ W_{CB}}{n(SR)\ T}\right)\frac{24.45}{MW}\left(\frac{T + 273}{298} \cdot \frac{760}{P}\right)$$

where

W_{CF} = weight of analyte on exposed front strip corrected for blank, ng

W_{CB} = weight of analyte on backup strip corrected for blank, ng

SR = passive sampling rate, cm^3/min.

Other quantities are as defined for the adsorbent tubes. The pressure correction was not applied as all samples were collected at sea level conditions.

The resulting concentration data are presented in subsequent sections of this report that deal with specific operations. For completeness, Table IV.4 summarizes the product abbreviation codes used throughout this report.

TABLE IV.4. PRODUCT ABBREVIATION CODE

<u>Compound Key</u>

ACT - Acetone
BNZ - Benzene
HPT - Heptane
HXA - Hexane
MEK - Methyl Ethyl Ketone
RFS - Refinery Feed Stock
THC - Total Hydrocarbon Concentration through Xylene, expressed as Hexane
TOL - Toluene
XLO,M,P - Meta-ortho, paraxylene

In order to characterize noise levels possibly unique to this ship, noise dosimetry data were collected utilizing the Metrosonics dB-301P/652 Metrologgers and Metroreader. These units were programmed with an 82 dB(A) criterion level, 80 dB(A) threshold level, and a 5dB exchange rate as recommended in USCG Navigation and Vessel Inspection Circular No. 12-82. The units sampled four times per second, and the L_{OSHA} exposure was computed using the following equation.

$$L_{OSHA} = 16.6 \text{ LOG } \frac{1}{480} \sum_{i=1}^{480} 10^{L_1/16.6} \quad (1)$$

where

L_1 is the sound pressure level (SPL) in dB.

The Metrologgers are capable of storing a maximum of 480 such values, providing a total sample duration of 16 hours when 2 minute averaging times are used. The system has a resolution of 1 dB and sampling range of 70 to 134 dB.

At the completion of the sampling durations these calculated value were printed by the Metroreader as a quasi-graphical time history. These data were used to make two graphs for each sample taken. The first graph represents a graphical display of the time history data in histogram form. The second graph shows the cumulative effective exposure during the course of the sample and the permissible exposure per NVC 12-82. The permissible exposures were calculated by the following equation.

$$(2) \quad L_{eff} = 16.61 \text{ LOG } \frac{1}{T} \sum_{i=1}^{m} 10^{L_{Ai}/16.61} \Delta t_i$$

where

L_{Ai} = A-weighted sound pressure level (dB(A)) during the i-th time interval, Δt_i

t_i = i-th time interval

$T = \sum_{i=1}^{m}$ = total time interval

TABLE V.7. SUMMARY OF NOISE DATA TAKEN ON MATES DURING PRODUCT DISCHARGING

Sample Number	Worker	Duration (min)	Noise Source	Max. Sound Pressure Level over 2 Minute Period (db(A))	Cumulative Exp. Over Monitoring Period (db(A))
8	2M	456	Cargo Pumps (5 products discharging)	112	89.8
10	3M1	165	Cargo Pumps (3 products discharging)	107	92.8
13	2M	199	Cargo Pumps (3 products discharging)	92	78.8

TABLE V.8. SUMMARY OF NOISE DATA TAKEN ON ABs DURING PRODUCT DISCHARGING

Sample Number	Worker	Duration (min)	Noise Source	Max. Sound Pressure Level over 2 Minute Period (db(A))	Cumulative Exp. Over Monitoring Period (db(A))
1	AB4	218	Cargo Pumps (6 products discharging)	95	85.6
3	AB1	215	Cargo Pumps (3 products discharging)	95	85.5
6	AB5	207	Cargo Pumps (3 products discharging)	95	80.3
11	AB6	129	Cargo Pumps (3 products discharging)	94	84.3
14	AB3	205	Cargo Pumps (3 products discharging)	95	82.3

Noise: The noise dosimetry data taken during product discharging are summarized in Tables V.7, V.8, and V.9 for Mates, ABs, and Pumpmen, respectively. Indicated in parenthesis in the noise source column of these tables are the number of products being discharged to give an indication of how many pumps may have been running. The area noise data taken during product discharging are shown in Table V.10. The noise dosimetry data for samples taken during discharging are presented in Appendix A.

Figure V.2 shows a set of noise data taken on the 2M during discharging. The peak noise levels coincide with times when the Mate was starting a cargo pump from on the deck.

On two occasions more than one noise sample was taken on an individual in a 24-hour time period. For these two cases the data are presented separately and also together assuming no exposure was received between the sampling periods. These results are also presented in Appendix A.

Protective Equipment

During the product discharge activities, chemical resistant gloves were occasionally worn by the workers while collecting product samples and handling hoses.

TABLE V.6. AREA SAMPLES TAKEN DURING DISCHARGE OPERATIONS

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)	Concentration (ppm)	Area
FT-14	26.7	31	6.2	LC	THC BNZ HXA	2839 23 685	125.6 1.1 30.3	By leaking flange at 10S (RFS)
62818	25.3	502	--	PC	THC	132	0.003	By Port Forward Manifold during discharge of Stoddard Solvents A and B, VM&P Naphtha, Aromatic Solvent and Toluene
FT-19	14.4	258	51.6	LC	THC	3685	18.8	By Aft Starboard Manifold containing several inches of Refinery Feed Stock
V6-13	20.0	59	12.0	SC	XLP	28	0.5	By Paraxylene Manifold Valve
V6-27	24.4	372	76.6	SC	THC TOL	422 62	1.6 0.2	By 4CF Pump Discharging Stoddard Solvent A
V6-10	16.1	146	29.49	SC	XLP	160	1.2	By workers changing a gasket in the XLP cargo line

* SC - small charcoal (100/50)
LC - large charcoal (400/200)
PC - passive charcoal

TABLE V.5. OCCUPATIONAL EXPOSURE MONITORING TAKEN DURING MISCELLANEOUS DISCHARGE OPERATIONS

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)	Concentration (ppm)	Personnel	Activity
FT-3	23.9	39	7.8	LC	THC	846	29.5	AB5	Pump out drip tray
V6-18	21.1	63	11.6	SC	THC XLP	56 39	1.4 0.7	OS1	Pump out drip tray
V6-20	22.2	24	5.0	SC	THC XLP	151 141	8.9 6.4	AB5	Pump out drip tray
V6-22	23.9	39	8.0	SC	THC	664	24.4	AB6	Pump out drip tray
FT-10	26.7	11	2.2	LC	THC	19	2.4	AB1	Clean spill from deck at 1OS (RFS)

* LC - large charcoal (400/200)
SC - small charcoal (100/50)

TABLE V.4. OCCUPATIONAL EXPOSURES DURING DISCHARGE TENDING - PUMPMEN

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
FT-18	17.8	433	89.2	LC	THC XLP	286 137	0.9 0.3	PM2
V6-1	25.8	206	41.4	SC	THC TOL	404 25	2.9 0.2	PM2
V6-6	25.3	241	48.9	SC	THC	653	4.0	PM1
V6-30	14.4	390	79.2	SC	ACT THC	ND 389	ND 1.4	PM2
V6-35	18.3	374	76.3	SC	THC XLP	367 285	1.4 0.9	PM1

* SC - small charcoal (100/50)
LC - large charcoal (400/200)
+ ND - not detectable

TABLE V.3. OCCUPATIONAL EXPOSURES DURING DISCHARGE TENDING - ABs

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
V6-2	25.8	208	42.2	SC	THC TOL	566 59	4.0 0.4	AB4
V6-4	25.3	231	46.4	SC	THC	745	4.8	AB2
V6-15	18.3	170	34.3	SC	THC XLP	162 149	1.4 1.0	AB1
V6-26	24.4	201	39.6	SC	THC TOL	566 46	4.2 0.3	AB3
V6-29	25.3	229	45.1	SC	THC TOL	145 ND	1.0 ND	AB1
V6-31	11.9	205	41.2	SC	ACT THC	270 12,380	3.3 84.9	AB5
V6-33	11.9	206	41.4	SC	ACT THC	840 4,713	10.3 32.2	AB6

* SC - small charcoal (100/50)
\+ ND - not detectable

TABLE V.2. OCCUPATIONAL EXPOSURES DURING DISCHARGE TENDING - MATES

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
V6-21	17.2	195	37.6	SC	ACT THC	ND 12	ND 0.1	2M
V6-28	20.0	122	23.6	SC	ACT THC	225 413	5.0 5.1	3M1

* SC - small charcoal (100/50)
\+ ND - not detectable

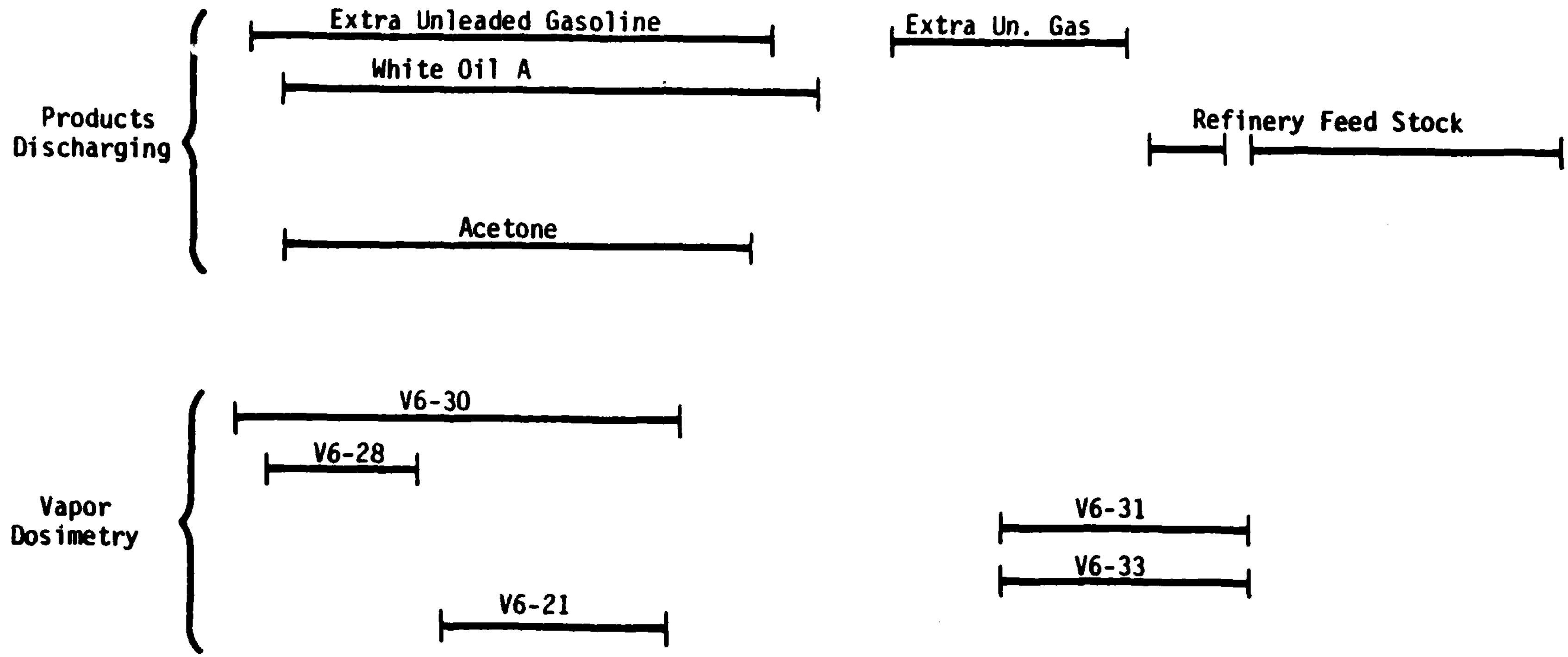


FIGURE V.1. CORRELATION OF VAPOR EXPOSURE SAMPLES WITH PRODUCTS BEING DISCHARGED (CONCLUDED)

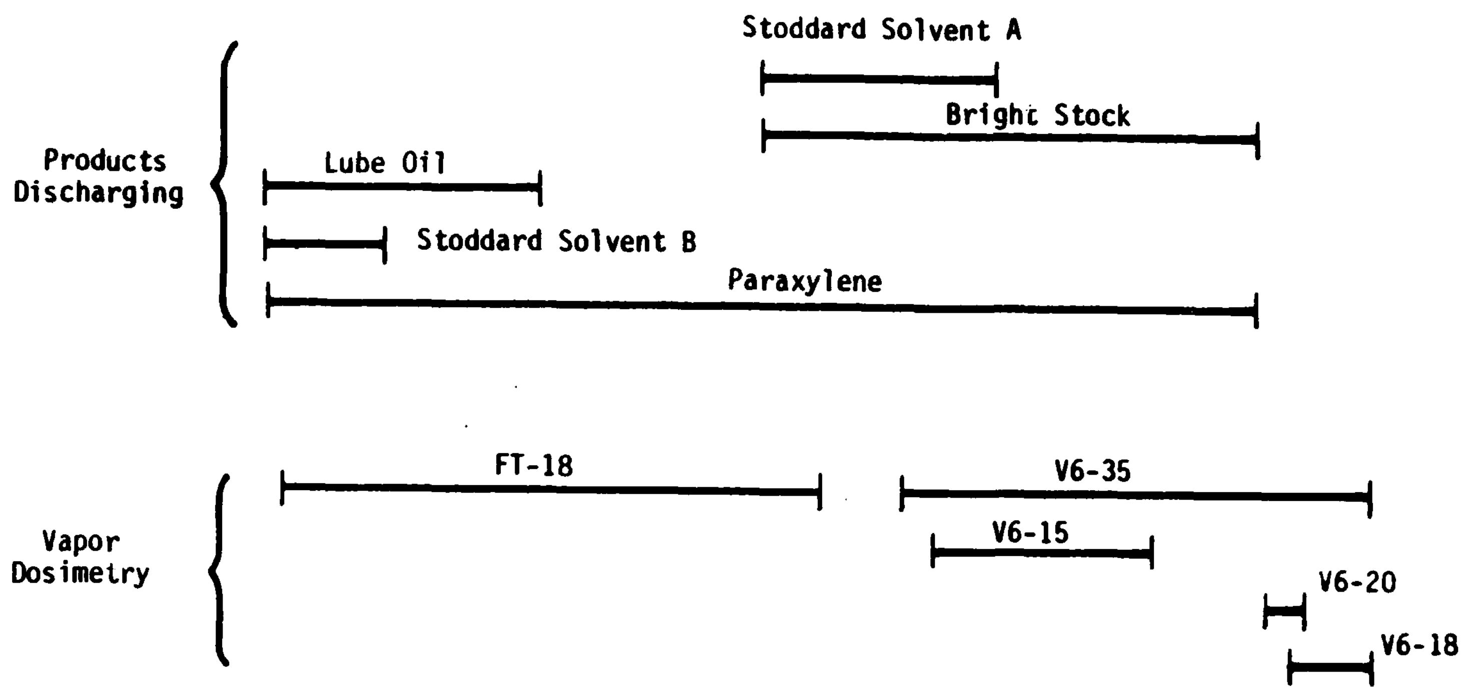


FIGURE V.1. CORRELATION OF VAPOR EXPOSURE SAMPLES WITH PRODUCTS BEING DISCHARGED (CONTINUED)

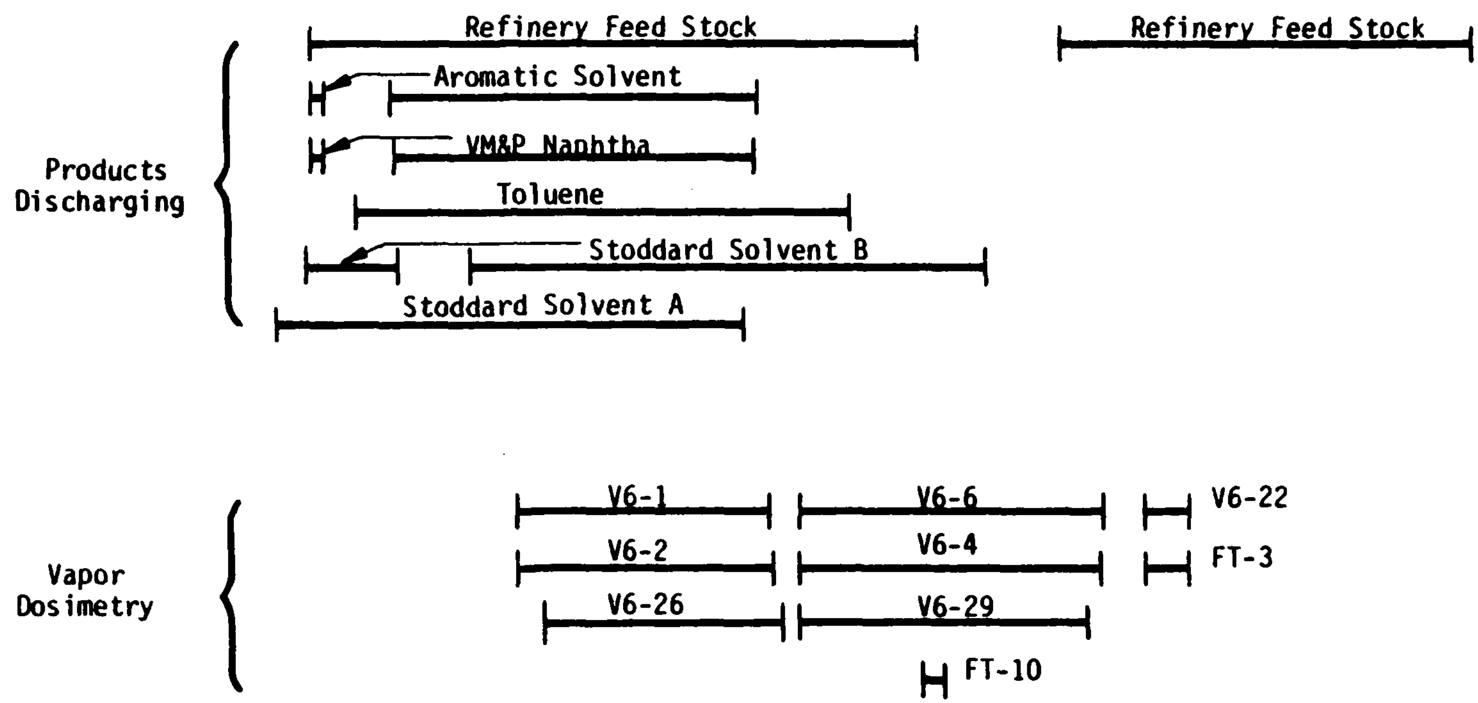


FIGURE V.1. CORRELATION OF VAPOR EXPOSURE SAMPLES WITH PRODUCTS BEING DISCHARGED

TABLE V.1. WORKER ACTIVITIES ASSOCIATED WITH PRODUCT DISCHARGING (Concluded)

Activity	Worker*		
	Mate	Pumpman	AB/OS
E. Discharge Monitoring			
1. Monitor status of tanks from cargo control room	X		
2. Periodic rounds on deck looking for problems	X	X	X
3. Repair leaks as necessary	0	X	X
4. Check valve line up for future transfers	0	0	
5. Monitor status of tanks from on deck	0	0	0
6. Jiggle tank gauging tapes	0	X	X
F. Discharge Stripping			
1. Stand by cargo pump for shut down	0	X	
2. Shut down cargo pumps	0	X	
3. Hook up compressed air to stripper pump		0	X
4. Start stripper pump	X	X	
5. Stand by and stop stripper pump	X	X	
6. Open and close stripper valve at manifold to drip tray			X
7. Close manifold valve	0	0	X
G. Line Blowdown			
1. Hook up air or inert gas	0	X	
2. Turn on line pressure	0	X	
3. Valve appropriately	0	X	
4. Open stripper valve at manifold to drip tray	0	0	X
H. Post Discharge Activities			
1. Make round with surveyor	X		0
2. Supervise hose disconnect	0	X	
3. Replace blinds on ship's manifold		X	0
4. Pump out drip trays to the slop line		0	X
5. Roll up tank gauging tapes		X	0
6. Disconnect jumper hoses		0	X
7. Stow jumper hoses			X
8. Help dock personnel with hose disconnect		0	0

* X - routinely
0 - occasionally

TABLE V.1. WORKER ACTIVITIES ASSOCIATED WITH PRODUCT DISCHARGING

Activity	Worker*		
	Mate	Pumpman	AB/OS
A. Prearrival Preparations for Discharge			
1. Set valve line up for discharge lines	X	X	
2. Line up crossovers and jumper hoses		X	X
3. Roll down tank gauging tapes		X	0
4. Recheck valve lineup	X	X	
B. Hose Hookup			
1. Oversee hose hookup	0	X	
2. Remove blinds from ship's manifold		X	0
3. Attach reducers where appropriate		X	X
4. Switch jumper hoses	0	0	X
5. Help dock personnel with hose hookup		0	0
C. Final Preparations for Cargo Transfer Prior to Pump Startup			
1. Recheck valve line up	X	X	
2. Make round with surveyor	X		0
D. Pump Startup			
. Start pump on slow from cargo control room	X		
2. Start pump on slow at pump	X	X	
3. Observe pressure gauges at pump	X	X	
4. Observe pressure gauges at manifolds			X
5. Adjust manifold valve on main cargo line			X
6. Adjust valve at pump	X	X	
7. Change pump speed to fast	X	X	
8. Restart pumps as necessary	X	X	

* X - routinely
0 - occasionally

V. Product Discharging

Product discharging was monitored closely on this voyage even though it is normally a low exposure potential situation. Monitoring was conducted during this portion of the voyage in order to observe any new technology being used during discharge and the resulting work procedures and associated exposure levels.

Worker Activities

The normal watch complement of workers during product discharging consisted of a Mate (deck officer), a Pumpman, and two ABs. During day hours, 0800-1700, an OS joined the watch complement and most often functioned as a third AB. The Chief Mate often assisted the Mate on watch and was on call during all shifts. The work responsibilities of each of these workers during product discharging, and its associated activities, are summarized in Table V.1.

Occupational Exposure Monitoring

Vapor: The occupational exposure monitoring samples taken during discharge tending are summarized in Tables V.2, V.3, and V.4 for Mates, ABs, and Pumpmen, respectively. Figure V.1 correlates the vapor exposure samples collected with the products being discharged for those samples summarized in Tables V.2, V.3, V.4, and V.5. Table V.5 summarizes occupational exposure monitoring taken during miscellaneous discharge operations including pumping out of drip trays and spill cleanup. Area samples taken during discharge operations are summarized in Table V.6.

This equation assumes a 5 dB exchange rate, and all levels below 80 dB(A) may be disregarded. Cumulative effective exposure graphs are not included for area noise samples since they are not representative of actual exposures.

TABLE V.9. SUMMARY OF NOISE DATA TAKEN ON PUMPMAN DURING PRODUCT DISCHARGING

Sample Number	Worker	Duration (min)	Noise Source	Max. Sound Pressure Level over 2 Minute Period (db(A))	Cumulative Exp. Over Monitoring Period (db(A))
2	PM2	219	Cargo Pumps (6 products discharging)	100	86.1
4	PM1	242	Cargo Pumps (3 products discharging)	92	84.9
7	PM1	451	Cargo Pumps (5 products discharging)	109	87.3
9	PM2	243	Cargo Pumps (3 products discharging)	99	83.9
12	PM2	400	Cargo Pumps (3 products discharging)	110	86.5
16	PM1	142	Cargo Pumps and Coppus Blowers (3 products discharging)	92	78.5
20	PM2	434	Cargo Pumps (3 products discharging)	110	87.7

TABLE V.10. AREA NOISE DATA TAKEN DURING PRODUCT DISCHARGING

Sample Number	Duration (min)	Noise Source	Max. Sound Pressure Level over 2 Minute Period (dB A))	Cumulative Effective Exposure over Monitoring Period (dB(A))
19	72	Cargo Pump 5P on slow	81	81.0

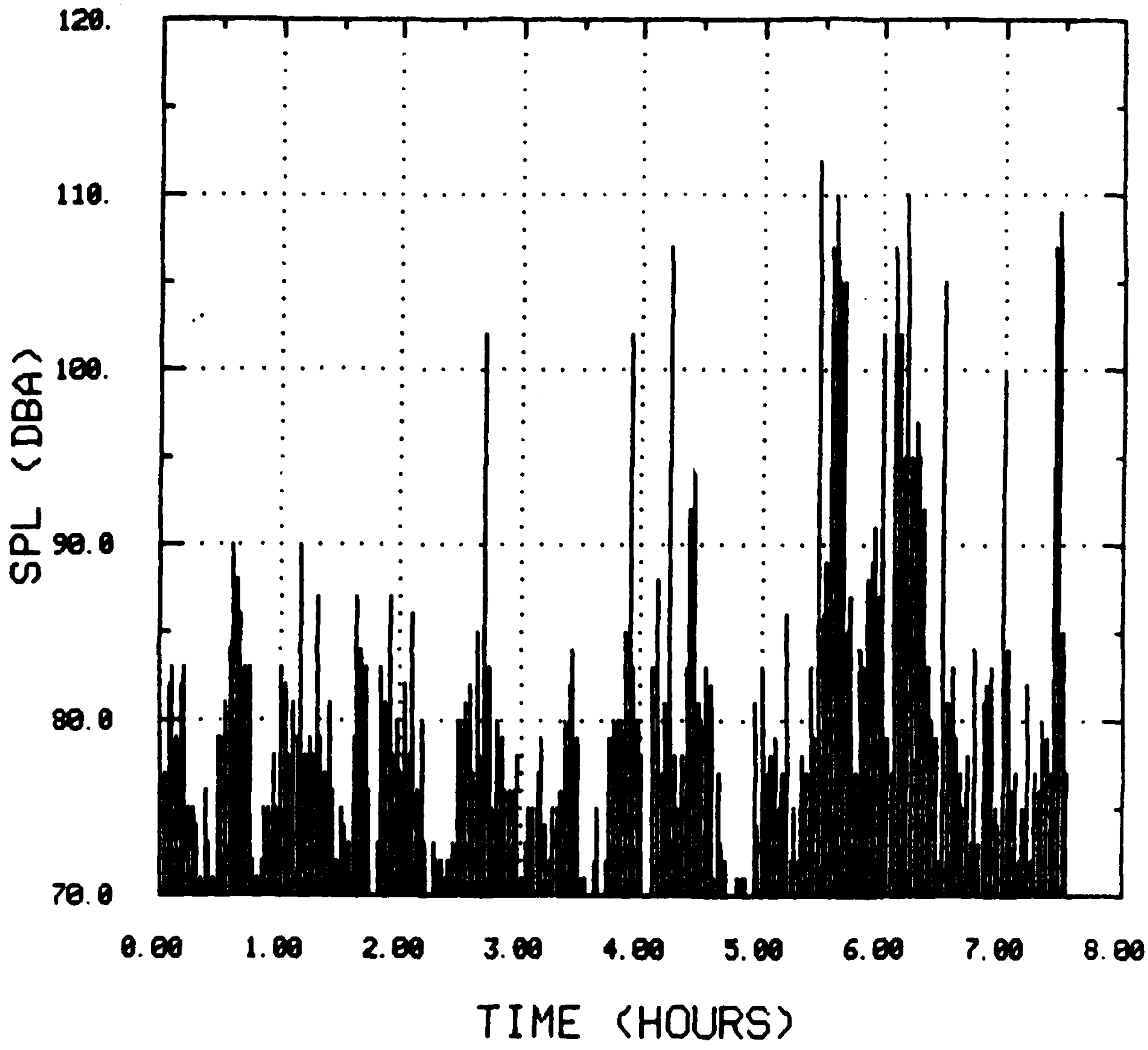


FIGURE V.2. NOISE DOSIMETRY DATA - SAMPLE 8

VI. Tank Processing

Many of the cargo tanks were processed during this voyage as summarized in Table VI.1. The reasons for the processing of these tanks were

- o to ensure the quality of the next cargo to be loaded into the tank,
- o to replace a cargo pump, and/or
- o to enable tank entry for the purpose of installing permanent, in-tank stripping pumps (a non-routine activity)

The design philosophy that has been used on other modern parcel chemical tankers and was used on this vessel incorporates tanks that are void of internal structure and tank bottoms that slope to the main cargo pump sump. These features promote more efficient product discharge and *tank washing*.

Tank Processing Methods

In general, there were several methods used for processing of the cargo tanks. The method used for processing a particular tank was determined by what equipment for washing and stripping was permanently installed in the tanks.

A. For tanks with fixed, in-tank washing machines and permanent, in-tank stripping pumps the processing procedure was as follows.

1. The washing was begun by opening the appropriate valves that sent wash water to the Butterworth machine.

TABLE VI.1. TANK PROCESSING SUMMARY

Tank No.	Reason for Processing	Previous Cargo	Tank Washing*	Tank Stripping		Tank Ventilation		
				Permanent	Portable	DHA+	Inert Gas	Coppus Blower
1P	Cargo Quality Control	Paraxylene	20CF (F)	X		X		
1C	Cargo Quality Control	Stoddard Solvent A	20CF (F)	X		X		
1S	Cargo Quality Control	Aromatic Solvent	20CF (F)	X		X		
2P	Cargo Quality Control	Stoddard Solvent B	20CF (F)	X		X		
2CF	Cargo Pump Replacement	Toluene	20CF (F)	X		X		
2S	Cargo Quality Control	VM&P Naphtha	20CF (F)	X		X		
3C	Cargo Quality Control	Stoddard Solvent A	20CF (F)	X		X		
3S	Cargo Quality Control	Isoparaffinic Solvent	20CF (F)	X		X		
4CF	Cargo Quality Control	Stoddard Solvent A	20CF (F)	X		X		
4CA	Cargo Quality Control	Acetone	20CF (F)	X		X		X
4CA	Cargo Quality Control	Methyl Ethyl Ketone	(F)	X		X		
5CA	Cargo Quality Control	Paraxylene	5CF,30HF (F,P)	X		X		
6CF	Cargo Quality Control	Isoparaffinic Solvent	5CF,30HF (P)		X	X		
7P	Stripper Pump Installation	Process Oil B	5CF,40HS,20HF (P)		X	X		
7CF	Cargo Quality Control	White Oil B	40HS,20CF,180HS,20CF (F)		X	X		
7S	Stripper Pump Installation	Process Oil A	5CF,40HS,20HF (P)		X	X		
8P	Stripper Pump Installation	Refinery Feed Stock	40HS,20HF (P)		X	X	X**	
8CF	Cargo Quality Control	Bright Stock	None		X	X		
8S	Stripper Pump Installation	Refinery Feed Stock	40HS,20HF (P)		X	X	X**	
10S	Cargo Quality Control	Wash Slops	(F)	X			X	
11PF	Cargo Quality Control	Paraxylene	5CF,40HS,20CF (F,P)	X		X		
11C	Stripper Pump Installation	Extra Unleaded Gasoline	40HS,20CF (F)	X		X	X**	

* Tank washing code indicates time in minutes and type of wash water.
CF = cold fresh, HF = hot fresh, HS = hot salt
For example, 20 CF means a wash for 20 minutes with cold, fresh water.
Codes in parenthesis indicated if fixed (F) or portable (P) washing machines were used.

** Inert gas ventilation was used on these tanks during tank washing.
\+ *DHA = dehumidified air*

2. The cargo pump for that tank was started to prevent a large volume of wash water from accumulating in the tank. This also ensured a good tank bottom wash.

3. During the washing, the tank was sometimes ventilated with either inert gas (IG) or dehumidified air (DHA). If the tank already contained inert gas, then inert gas was supplied during the washing.

4. The p/v valve bypass riser line was opened to allow atmospheric venting well above deck level. All other tank openings were normally closed.

5. Upon completion of the washing procedure, the appropriate valves were closed to stop the flow of wash water.

6. Just as the cargo pump was about to lose suction the cargo pump was turned off.

7. The stripper pump was then started to strip the remaining liquid from the tank.

8. When the stripper had removed almost all of the liquid, a valve on the stripper line was opened by the tank which allowed the sump to be stripped more completely. This resulted in wash water flowing onto the deck. The pumpman would often let the liquid spray onto his hand then smell his hand for residual product vapors. In one case a tank was rewashed because of a distinct smell of the residual chemical during this "test".

9. When the wash water stopped flowing from the open valve onto the deck, the stripper pump was turned off.

10. If the tank was not yet being ventilated the DHA ventilation was turned on at this point. If the tank had been washed under inert gas the inert gas was turned off and DHA was turned on. If the tank was already being ventilated with DHA, ventilation was continued. In one instance two Coppus blowers were used in addition to the DHA system to speed the ventilation process.

11. Ventilation was continued for as long as possible or as long as necessary. Ventilation times ranged from several hours to an entire day.

B. For tanks with fixed, in-tank washing machines but no permanent stripping pumps the processing procedure was as follows.

1. The washing, liquid removal using the cargo pump and initial ventilation followed steps A1, A2, A3, A4, A5, and A6 as discussed above.

2. Since the tanks were not equipped with permanent stripping pumps the next step was to ventilate the tank as described in steps A10 and A11 above to prepare the tank for entry.

3. After appropriate ventilation, a given tank was tested and eventually entered for stripping with a portable diaphragm pump and possible further cleaning using a squeegee, bilge pump, and rags. The work performed during the tank entry portion of the processing procedure is further explained in Section VII, Tank Entry.

C. For tanks that were not equipped with fixed, in-tank washing machines, the processing procedure was as follows.

1. The tank to be processed was prepared for washing with portable machines by opening the appropriate Butterworth deck plates. The washing machine was attached to the wash hose then dropped through the deck opening into the tank. A hose holder was then fit over the opening. The hose was dropped to the first washing depth then secured with a rope to the holder.

2. The wash water was turned on to commence the washing.

3. The cargo pump for that tank was started as discussed in step A2 above.

4. Ventilation was supplied to the tank as described in steps A3 and A4 above.

5. Throughout the washing it was necessary to drop the washing machines to different heights in the tank. This entailed untieing the secured hose, allowing the hose to drop the appropriate amount, and resecuring the hose with the rope.

6. At the completion of washing the wash water was stopped, hoses removed from the tank, and Butterworth deck plates replaced.

7. The stripping and ventilation activities were as described in steps A6 through A11 above for tanks with permanent, in-tank strippers or as described in steps B2 and B3 above for tanks with no permanent stripping pumps.

Traditionally, tanks on parcel chemical and product tankers have been washed using portable washing machines that are manually lowered into the tank. Tanks are normally ventilated after washing. The two operations do not normally occur simultaneously.

No matter which method was used, part of the washing procedure involved clearing the deck piping of residual liquid. This was accomplished by opening the drain line at the appropriate manifold(s) and allowing the line to drain into the drip tray. This drip tray was then emptied into the slop line using a diaphragm pump.

<u>Worker Activities</u>

The people most intimately involved in the tank processing were the Pumpmen, the Able-Bodied Seamen (ABs), the Ordinary Seamen (OS), and the Chief Mate (CM). Occasionally another deck officer would assist the CM. The team of workers usually consisted of two pumpmen, 3 ABs, 1 OS, and the CM. The individual roles of these workers are summarized in Table VI.2.

<u>Tank Washing</u>

The tank washing procedures varied from tank to tank but were generally dependent on the type of cargo previously in the tank, type of cargo to be loaded into the tank, and configuration of the tank.

Three types of wash water were used.

- o cold fresh water (CF)
- o hot fresh water (HF), or
- o hot salt water (HS).

The types of washes used for each tank are summarized in Table VI.1. In general the wash times were a multiple of 20 minutes since that was the time that it took the Butterworth machines to complete a full wash cycle. The 5-minute cold fresh water wash/strip/blow procedure was completed prior to several hot water washes to reduce the vapor concentrations in the tank to well below the LEL.

TABLE VI.2. TANK PROCESSING WORK ACTIVITIES

Activity	Worker*			
	Pumpmen	AB/OS	CM	Mate
1. Hookup jumper hoses for washing	X	X		
2. Start and stop fixed washing machines	X			
3. Setup of portable washing machines	0	X		
4. Handling of washing hoses	0	X		
5. Start and stop cargo pumps	X		0	
6. Start and stop ventilation	X		0	
7. Open p/v valve bypass line	X			
8. Start and stop permanent stripping pumps	X			
9. Open deck valve at end of stripping when using permanent strippers	X			
10. Smell wash water for product odor	X			
11. Tank atmosphere testing			X	0
12. Stripping tank bottom with portable diaphragm pump		X		
13. Squeegee tank bottom		X		
14. Pump out sump with bilge pump		X		
15. Dry tank bottom with rags		X		
16. Draining of deck piping into the drip tray	X	X		
17. Pumping of liquid in drip tray to slop line	0	X		
18. Disconnect and drain jumper hoses	0	X		

* X - routinely
0 - occasionally

The tank washing using portable washing machines was accomplished by using either two or three different drops. For washing with two drops the distances the machines were lowered into the tank were 15 and 40 feet. For washing with three drops the distances were 15, 25, and 40 feet.

Occupational Exposure Monitoring

Vapor: The occupational exposure vapor samples taken during tank processing are summarized in Tables VI.3 and VI.4 for ABs and Pumpmen, respectively. Table VI.5 presents an area sample taken during tank processing. Figure VI.1 correlates the vapor exposure samples collected with the products in the tanks being processed for those samples summarized in Tables VI.3, VI.4, and VI.5.

Noise: The noise measurements taken during the processing of the tanks, excluding tank entries which will be discussed in the next section, are summarized in Table VI.6. The noise dosimetry data for these samples are presented in Appendix B.

Sample 24 was taken on a pumpman who was processing six tanks. The major noise sources to which the pumpman was exposed to were the cargo pumps. As discussed earlier, the pumpman is responsible for starting and stopping these pumps as well as ensuring that suction is not lost. Other sources of noise during this time period were minor but included noise from the in-tank stripper and the wash water hitting the deck.

Sample 15 was taken in an area where two Coppus blowers were used to supplement the DHA system and speed the ventilation process. These blowers were in a very shielded area. Workers were required to spend some time in this area to finish the stripping activity. The total time spent in this area totaled only several minutes.

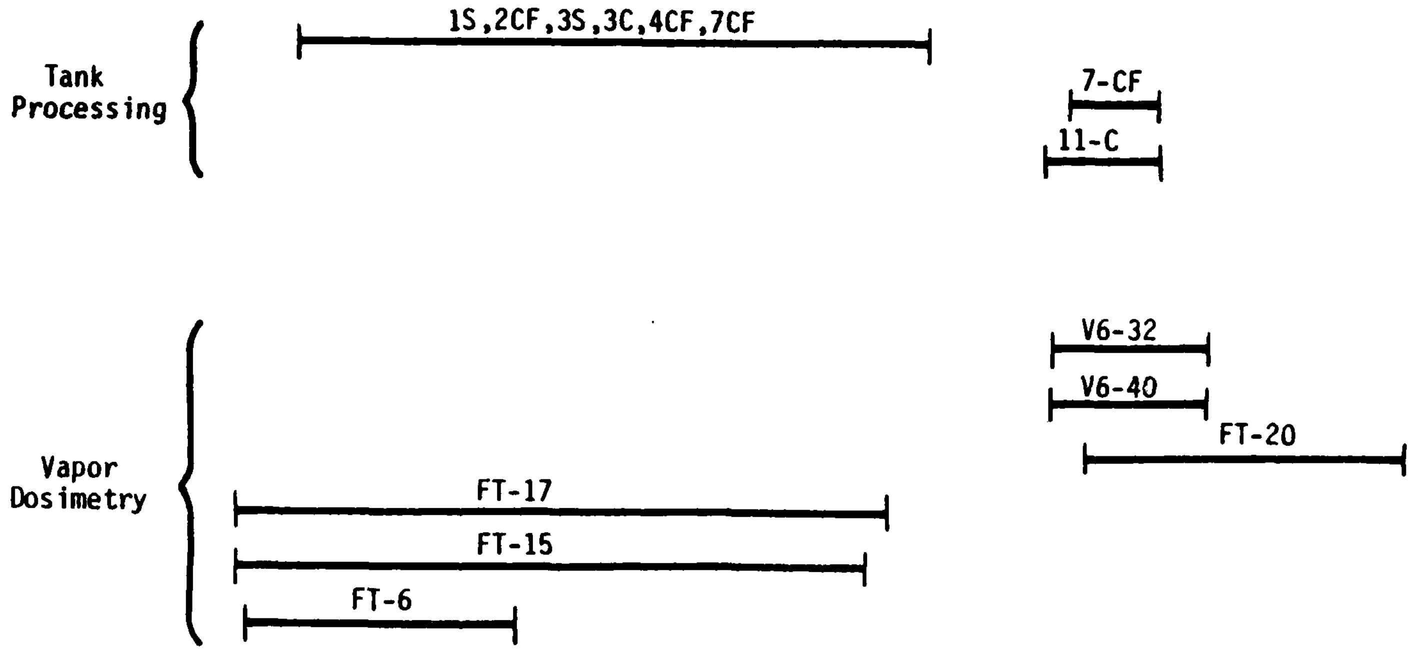


FIGURE VI.1. CORRELATION OF VAPOR EXPOSURE SAMPLES WITH TANKS BEING PROCESSED

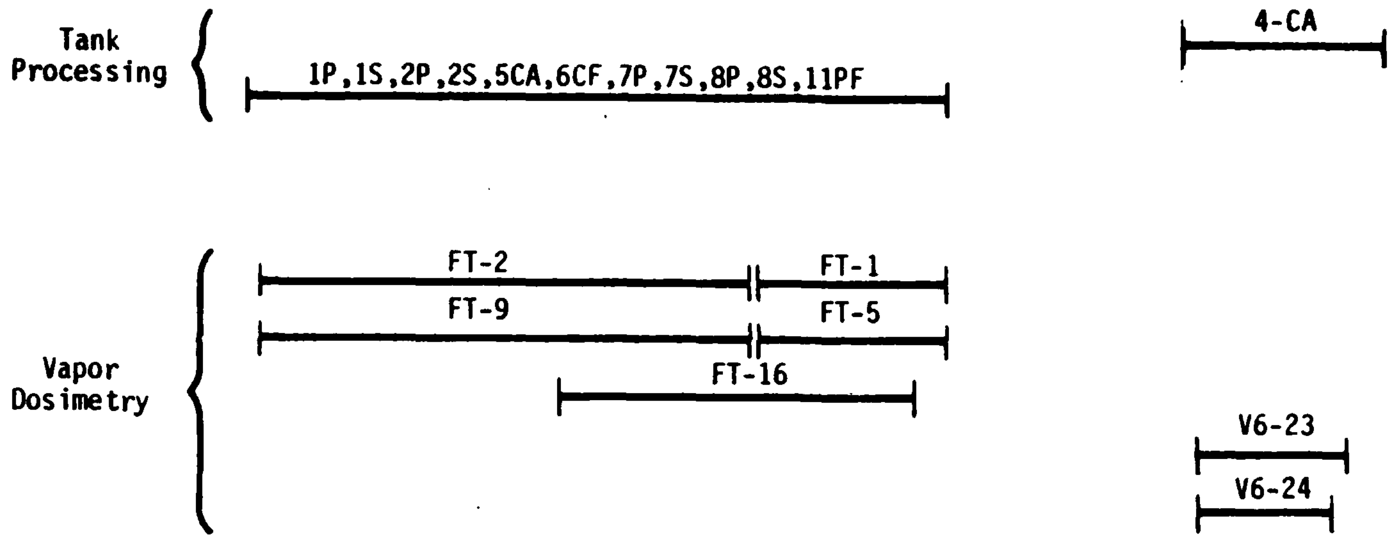


FIGURE VI.1. CORRELATION OF VAPOR EXPOSURE SAMPLES WITH TANKS BEING PROCESSED (CONCLUDED)

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)	Concentration (ppm)	Personnel
FT-6	25.8	212	42.2	LC	THC	1000	6.5	AB1
FT-16	26.7	297	58.2	LC	THC XLP	2957 1124	13.9 4.4	AB5
V6-23	13.3	117	23.5	SC	ACT THC	190 255	4.1 3.1	AB1
V6-24	13.3	107	20.7	SC	ACT THC	640 474	15.8 6.5	AB2

* SC - small charcoal (100/50)
LC - large charcoal (400/200)

TABLE VI.4. OCCUPATIONAL EXPOSURES DURING TANK PROCESSING - PUMPMEN

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(µg)	Concentration (ppm)	Personnel
FT-1	31.1	147	29.4	LC	THC	565	5.4	PM1
FT-2	31.1	399	79.8	LC	THC XLP	11747 3250	41.0 9.4	PM1
FT-5	31.1	147	29.4	LC	THC	410	3.9	PM2
FT-9	31.1	398	79.6	LC	THC XLP	6979 2680	24.4 7.8	PM2
FT-15	25.6	507	101.9	LC	THC TOL	4937 1400	13.2 3.7	PM1
FT-17	25.6	526	106.3	LC	THC TOL	2052 186	5.3 0.5	PM2
V6-32	25.6	123	24.9	SC	THC	415	5.0	PM1
V6-40	26.5	124	24.4	SC	THC	63	0.8	PM2

* SC - small charcoal (100/50)
LC - large charcoal (400/200)

/eight to descend into the tank and readings to be taken. The portable ;ystem is fitted with (1) a seal at the pipe/monitor interface and (2) :lastomeric wipers by the tape in order to minimize vapor discharge, and :hus occupational exposures, during tank top off.

Gauging of a tank with the portable system usually began with five feet to go in the loading, although this varied to as low as two feet to go during busy periods. The worker assigned to perform the top off gauging would remove the cover on the mounting pipe and then attach the portable unit. The valve in these mounting pipes did not have a positive seal and thus the workers were exposed to the vapors emitted from the tank. After the portable unit was in place and the valve in the pipe was opened the positive pressure in the tanks permitted some vapor to escape at the wiper/tape interface and the riser screw connections.

Various workers used the portable restricted gauging device in different ways. The method used by AB5 and OS1 was to constantly take readings during the entire time they were topping off the tank. This resulted in their breathing zone being approximately two feet away from the vapor sources discussed above. This distance was reduced to the order of a few inches when the audible alarm could not be heard because of the noise emitted from activated high velocity vents. 3M2, 3M3, and AB4 took frequent readings but would stand up and away from the portable between readings. (The frequency of readings was determined by how fast the level was changing). 3M3 used a rag wrapped around the portable unit by the tape wiper to reduce the jet of vapor emitted from this source. AB3 and OS2 set the portable gauge tape to the reading of interest and then stood back and listened for the audible alarm indicating that the liquid had reached the tape bottom. The tape was then reset to the next reading of interest and the process continued. The end of a tank loading, however, required constant gauging for the last several inches.

TABLE VIII.1. WORKER ACTIVITIES ASSOCIATED WITH PRODUCT LOADING (Concluded)

Activity	Worker		
	Mate	Pumpman	AB/OS
E. Continued			
4. Check valve line up for future transfers	0	0	
5. Close cargo valve at manifold at completion of loading	0	X	X
6. Monitor status of tanks from on deck	0	0	0
7. Jiggle tank gauging tapes	0	X	X
F. Tank Top Off			
1. Observe tank gauging readouts in cargo control room	X		
2. Use portable restricted gauging device		0	X
3. Close valves after shore line blowdown	0	X	X
4. Keep tank gauging tape from sticking	0	X	X
5. Observe tank gauging readouts on deck	0	X	X
G. Post Loading Activities			
1. Make round with gauger	X		0
2. Supervise hose disconnect	0	X	
3. Replace blinds on ship's manifold		X	0
4. Pump out drip trays to the slop line		0	X
5. Roll up tank gauging tapes		X	0
6. Disconnect jumper hoses		0	X
7. Stow jumper hoses			X
8. Help dock personnel with hose disconnect		0	0

* X - routinely
  0 - occasionally

TABLE VIII.1. WORKER ACTIVITIES ASSOCIATED WITH PRODUCT LOADING

Activity	Worker*		
	Mate	Pumpman	AB/OS
A. Prearrival Preparations for Discharge			
1. Set valve line up for discharge lines	X	X	
2. Line up crossovers and jumper hoses		X	X
3. Roll down tank gauging tapes		X	0
4. Recheck valve line up	X	X	
B. Hose Hookup			
1. Oversee hose hook up	0	X	
2. Remove blinds from ship's manifold		X	0
3. Attach reducers where appropriate		X	X
4. Switch jumper hoses	0	0	X
5. Help dock personnel with hose hookup		0	0
C. Final Preparations for Cargo Transfer			
1. Recheck valve lineup	X	X	
2. Make round with surveyor	X		0
D. Loading Startup			
1. Observe pressure gauges at manifolds			X
2. Adjust manifold valve on main cargo line			X
3. Observe tank gauging readouts at tank	0	X	X
4. Observe tank gauging readouts in cargo control room	X		
E. Loading Monitoring			
1. Monitor status of tanks from cargo control room	X		
2. Periodic rounds on deck looking for problems	X	X	X
3. Repair leaks as necessary	0	X	X

VIII Product Loading

The products loaded at the final terminal are summarized in Table III.2.

Worker Activities

The normal watch complement of workers during loading was the same as for discharging, that is a Mate, a Pumpman and two ABs with possibly an additional Mate and/or day OS. The work responsibilities of each of these workers during product loading, and its associated activities, are summarized in Table VIII.1.

Many of the activities performed during product loading were identical to activities performed during discharging. One of the additional activities which took place during loading is tank top off.

Tank top offs were performed in one of two fashions. One method was to simply use either of the two closed gauging systems that were permanently installed in each tank. This top off procedure required one person, usually an AB or PM, at the gauge site to jiggle the tape (to ensure proper readings) and obtain ullage readings. Usually a Mate was also reading the ullages from the instrument readouts in the cargo control room.

The other method of topping off tanks involved the use of the third gauging system, the portable restricted gauging system. The device is an intrinsically safe, ullage monitor that provides a digital display of cargo temperature in addition to an audible sound when the tape weight contacts the liquid surface. The portable monitor mounts via a threaded connection onto a deck riser pipe near the pump column. The deck riser pipe is fitted with a valve, which is normally closed, downstream of where the monitor attaches. This valve is opened in order to permit the tape

TABLE VII.4. SUMMARY OF IN-TANK NOISE DATA

Sample Number	Worker	Duration (min)	Activity	Noise Source	Max. Sound Pressure Level over 2 Minute Period (db(A))	Cumulative Exp. Over Monitoring Period (db(A))
21	OS1	23	Stripper pump suction hose handling	Portable stripper pump, DHA	106	95.0
22	SwRI	20	Observe work activities	DHA	92	87.9
23	SwRI	32	Observe stripping operation	Portable stripper pump, DHA	93	87.9
25	AB2	41	Stripper pump suction hose handling	Portable stripper pump, DHA	106	95.5
26	AB6	37	Stripper pump operation	Portable stripper pump, DHA	110	101.0

For those samples where the worker wore some respiratory protection, the actual exposure received does not equal, and should have been less than, the exposure measured by the dosimetry device. Samples SC-82, V6-16, and V6-38 were taken on the CM during tank atmosphere testing. Samples SC-80 and V6-12 were taken on various workers during the opening of blanked-off stripper lines. Sample SC-87 was taken on an AB who was involved in tank stripping and then opening of the blanked-off stripper lines. Samples SC-86 and SC-84 were taken on the pumpmen during intake maintenance activities. The remainder of the samples were taken during tank stripping and/or squeegeeing/towel drying activities as outlined in Table VII.1.

Noise - The noise measurements taken during the tank entries are summarized in Table VII.4. Samples 22 and 23 were placed on project team members to obtain background noise levels in the tanks during operations with ventilation air only and portable stripper pump operation, respectively. The noise dosimetry data for these samples are presented in Appendix C.

Protective Equipment

During the stripping and squeegee/towel drying activities the workers generally, but not consistently, wore hard hats and chemical resistant gloves. At least one of the workers in the tank carried a two-way radio allowing communication with the workers on deck.

Organic vapor cartridge respirators were worn by the ABs and the Chief Mate from just before the blanked off lines in 7P, 7S, 8P, and 11C were opened until the workers exited the tanks. Chemical resistant gloves were also worn during this operation.

As stated earlier, the Chief Mate wore an SCBA (MSA Model 401) during initial testing of the tank atmospheres in 8P, 8S, and 11C. He also wore an SCBA during blank removals in 8S.

Hearing protection was not worn by the workers entering the tanks.

TABLE VII.3. OCCUPATIONAL EXPOSURES DURING TANK ENTRY

Tank Number	Sample Number	T (°C)	Duration (min)	Volume (L)	Trap*	Chemical	W_c (µg)+	Concentration (ppm)+	Personnel	Respiratory Protection Worn	Product In Tank
6CF	SC-89	25.8	23	4.5	SC	THC	289	18.9	SwRI	None	Isoparaffinic Solvent
5CA	SC-84	27.8	18	3.6	SC	XLP	86	5.7	PM2	None	XLP
7P	M-145	25.0	73	103.4	Filter	Process Oil B	ND	ND	AB2	None	Process Oil B
7P,8P	SC-80	25.0	88	17.3	SC	THC	138	2.4	CM	Organic Vapor Cartridge	Process Oil B, RFS
8P	SC-82	25.0	19	3.5	SC	THC	22	1.9	CM	SCBA	RFS
8P	SC-88	25.6	10	2.02	SC	THC	44	6.5	OS1	None	RFS
8S	V6-49	25.6	25	5.05	SC	THC	61	3.6	OS1	None	RFS
8S	V6-16	25.6	12	2.4	SC	THC	11	1.4	CM (2nd entry)	SCBA	RFS
11C	SC-87	26.4	72	13.3	SC	THC	1685	37.8	AB6	Organic Vapor Cartridge for last 30 minutes	Unleaded Gas
11C	V6-12	26.4	47	9.5	SC	THC	3906	122.7	CM	Organic Vapor Cartridge	Unleaded Gas
11C	V6-38	26.1	16	2.9	SC	THC	30	3.0	CM	SCBA	Unleaded Gas
11PF	SC-86	27.8	16	2.9	SC	XLP	44	3.5	PM2	None	XLP

* SC - small charcoal (100/50)
Filter - mixed esters of cellulose filter
\+ ND - not detectable

In addition to the on-deck testing, the tank atmospheres for three tanks that had previously contained inert gas (8P,8S, and 11C) were tested internally. The Chief Mate entered these tanks using a self-contained breathing apparatus and equipped with an MSA 260 O_2/CGI instrument, an MSA 70 CO instrument, and Draeger pump and tubes (CO and NOx). The Chief Mate surveyed the tanks' atmospheres with the MSA 260 for oxygen and combustible gas, MSA 70 for carbon monoxide, and Draeger tubes for carbon monoxide and nitrous oxides.

The tank atmosphere measured by the Chief Mate inside 8P and 11C were 20.8% O_2, 0% LEL, 0 ppm CO, and 0 ppm NO + NO_2. The initial atmosphere inside 8S was measured by the MSA 260 and MSA 70 to contain 20.8% O_2, 0% LEL, and 0 ppm CO. However, the Chief Mate, while still wearing the self-contained breathing apparatus, removed the blanks from the stripper line flanges. A high pressure stream of inert gas and liquid product was released into the tank from these lines. Subsequent to this event the atmosphere in the center bottom of the tank was tested and found to contain 20.8% O_2, up to 40% LEL, up to 500 + ppm CO, and 0 ppm NO + NO_2. After appropriate ventilation the Chief Mate, again wearing an SCBA, reentered 8S to retest the environment. The atmosphere was measured to contain 20.8% O_2, 0% LEL, 0 ppm CO, and 0 ppm NO + NO_2. The workers were then allowed inside 8S.

At each tank the MSA 260 was left on the deck with the dropline into the tank as a monitor during the entire tank entry. The % O_2 and % LEL alarms were set at 16 and 50, respectively. The MSA 70 was also left on the deck with a dropline into the tank at the three previously inerted tanks (8P,8S, and 11C).

Occupational Exposure Monitoring

Vapor - The occupational vapor exposure samples taken during tank entries are summarized in Table VII.3. This table also summarizes the respiratory protection worn by the workers during the tank entries.

Two tanks were entered (5CA and 11PF) to replace inoperable, fixed Butterworth washing machines with spare operational machines. This operation involved the two pumpmen. One of the pumpmen entered the tank and climbed to the top of the Butterworth stand where he removed the bolts from the flange. From the deck level, the other pumpman dropped a rope into the tank by the inoperable washing machine. When the pumpman inside the tank had secured the inoperable machine to the rope, the pumpman on the deck would hoist the machine out of the tank and then lower the new machine into the tank. The pumpman in the tank then secured the machine to the Butterworth stand and exited the tank.

During the in-tank operations, ventilation air was provided to all but two of the tanks (11PF and 5CA).

Tank Atmosphere Testing

All of the tanks entered had previously been processed as explained in Section VI, Tank Processing. In summary, all but one of the tanks entered had been washed and ventilated. The remaining tank, which previously carried bright stock, had been ventilated but not washed.

A tank entry procedure and permit system had been developed by the company and copies of the blank permits were available on the ship. Preentry gas and vapor atmosphere tests were conducted as required on the permit.

The tank atmospheres of each of the tanks entered were tested by either the CM or 2M for oxygen and combustible gas concentrations prior to entry. This was accomplished using an MSA 260 O_2/CGI instrument with an appropriate length dropline. All measurements from the main deck indicated safe tank conditions of 20.8% O_2 and 0% LEL. Three of these tanks, which had been inerted, were also checked with an MSA 70 from the deck level for CO concentration. All concentrations from the main deck indicated 0 ppm CO.

Stripping of residual liquid from the tank bottoms and sumps was necessary in all of the processed tanks that were not equipped with permanently-installed in-tank strippers. This operation usually involved two ABs in the tank and two ABs at the expansion trunk on the deck. The ABs on the deck lowered, then later raised, equipment necessary for the operation in the tank, including a portable stripper pump, compressed air hose (for powering the pump), pump discharge hose, and pump suction hose. The ABs in the tank connected the hoses to the pump and then worked together to strip the tank. One AB would sit or stand by the pump to control the pump speed. The other AB handled the pump suction hose to strip the liquid from the tank bottom and the sump. He was always within 10 feet of the pump and was usually working against a wall or in a corner while stripping the sump.

Squeegeeing and towel drying the tank bottoms and sumps was necessary in those processed tanks which required strict quality control for the product which was due to be loaded next into the tanks. This operation usually involved two or three ABs in the tank and two ABs at the expansion trunk on the deck. The ABs on the deck lowered, then later raised, equipment necessary to the operation into the tank, including a manually-operated bilge pump, bucket, squeegees, and rags. The ABs in the tanks would squeegee the liquid to the sump then use the bilge pump to empty the sump into the bucket. The tank bottom and sump were then wiped with rags to get them completely dry.

Five of the tanks entered (7P,7S,8P,8S,11C) were being prepared for the installation of fixed stripper pumps onto the previously installed, and blanked stripper lines in the tanks. To completely clean the tank and piping in the tank, the blanks were removed from these stripper lines. The liquid was drained into a bucket and the lines were then blown with compressed air to remove as much liquid from the lines as possible. This operation involved the Chief Mate and one or two ABs to assist him.

TABLE VII.2. SUMMARY OF IN-TANK WORK ACTIVITIES

Activity	Worker*		
	Mate	Pumpman	AB/OS
1. Tank atmosphere testing	X		
2. Operating portable diaphragm pump			X
3. Handling of portable pump suction line			X
4. Squeegee tank bottom			X
5. Pump out sump with bilge pump			X
6. Dry tank bottom with rags			X
7. Open blanked-off in-tank lines (one-time, non-routine activity)	X		X
8. Replace washing machines (an occasional activity)		X	

* X - routinely

VII. Tank Entries

During the ballast voyage, 10 cargo tanks, which had previously been processed, were entered.

In-Tank Work Activities

Tables VII.1 and VII.2 summarize the tank entries including information about the in-tank activities. The processing of these tanks was summarized in the previous section in Table VI.1. The work activities that required the tank entries were one or more of the following:

- o Stripping of residual liquid (lube oil or wash slops) from the tank bottom and sump for tanks without permanent stripper pumps.

- o Squeegeeing and towel drying the tank bottom and sump.

- o Opening of blanked-off in-tank lines to prepare for installation of stripping pumps, a one-time, non-routine operation.

- o Replacing of non-operational washing machines with new machines.

TABLE VII.1. SUMMARY OF IN-TANK WORK PERFORMED

Tank No.	In-Tank Work Activities		
	Strip	Squeegee/Towel Dry	Maintenance
5CA			X
6CF	X	X	
7P	X	X	X
7CF	X	X	
S	X	X	X
8P	X		X
8CF	X	X	
8S	X		X
11PF			X
11C	X	X	X

TABLE VI.6. TANK PROCESSING NOISE DATA

Sample Number	Worker	Duration (min)	Noise Source	Max. Sound Pressure Level over 2 Minute Period (db(A))	Cumulative Exp. Over Monitoring Period (db(A))
24	Pumpman 1	497	Cargo pumps, stripper pumps	109	83.4
15	Area Sample by Coppus blowers	165	2 Coppus blowers	104	100.6

Protective Equipment

During the tank processing activities, chemical resistant gloves were occasionally worn by the ABs and OS.

TABLE VI.5. AREA SAMPLES TAKEN DURING TANK PROCESSING

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c (μg)	Concentration (ppm)	Area
FT-20	26.7	11	2.2	LC	THC	35	0.2	In Bridge

* LC - large charcoal (400/200)

Occupational Exposure Monitoring

Vapor - The occupational vapor exposure samples taken during product loading monitoring are summarized in Table VIII.2. Table VIII.3 summarizes samples taken during tank top offs with the portable restricted gauging system.. Area samples taken during loading are summarized in Table VIII.4. Figure VIII.1 correlates the vapor exposure samples collected with the products being loaded for these samples summarized in Tables VIII.2 and VIII.4.

Noise - The noise measurements taken during product loading, including tank top offs, are summarized in Table VIII.5. Indicated in parenthesis in the noise source column of this table are the number of products being loaded to give an indication of how many high velocity vents may have been popping off. The noise dosimetry data for these samples are presented in Appendix D.

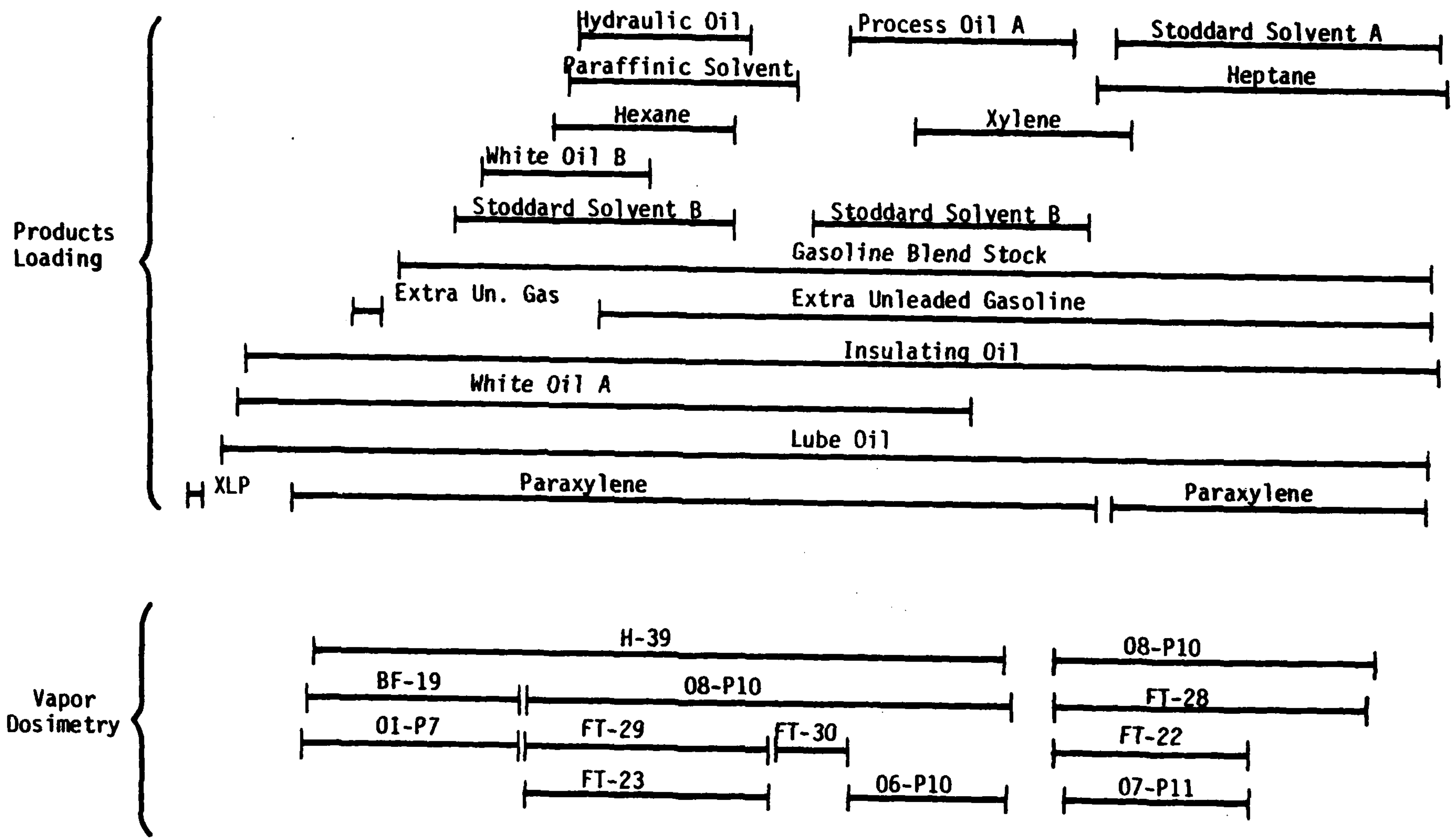


FIGURE VIII.1. CORRELATION OF VAPOR EXPOSURE SAMPLES WITH PRODUCTS BEING LOADED

TABLE VIII.2. OCCUPATIONAL EXPOSURES DURING PRODUCT LOADING MONITORING

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel
BF-19	26.1	204	40.4	LC	THC XLP	1574 9	10.7 0.1	AB2
FT-22	25.8	201	39.4	LC	HPT THC XLP	170 1808 176	1.08 12.6 1.01	AB2
FT-23	25.0	249	49.3	LC	HXA THC XLP	60 305 50	0.4 1.7 0.2	AB6
FT-29	25.0	249	49.3	LC	HXA THC XLP	ND 2439 ND	ND 13.5 ND	AB5
FT-30	24.4	76	15.2	LC	THC XLP	1131 102	20.3 1.5	AB3
01-P7	26.1	209	41.6	LC	THC XLP	499 131	3.3 0.7	AB1
06-P10	24.4	147	29.3	LC	THC XLP	3087 1524	28.7 11.8	AB4
07-P11	26.7	176	35.2	LC	HPT THC XLP	185 12,160 195	1.3 94.8 1.3	AB1
FT-28	26.4	309	61.8	LC	HPT THC XLP	125 1705 212	0.5 7.6 0.8	PM1
08-P10	25.0	471	92.3	LC	HXA THC XLP	860 5150 1024	2.7 15.2 2.5	PM2

* LC - large charcoal (400/200)
\+ ND - not detectable

TABLE VIII.3. OCCUPATIONAL EXPOSURES DURING TANK TOP OFF WITH THE PORTABLE RESTRICTED GAUGING DEVICE

Tank Number	Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c (μg)	Concentration (ppm)	Personnel	Product Loading
1C	V6-86	26.7	5	0.9	SC	THC	78	25.2	3M3	Stoddard Solvent B
2S	SC-85	25.0	10	1.8	SC	THC	49	7.9	AB6	Paraffinic Solvent
4CA	V6-34	12.2	29	5.9	SC	MEK	1010	66.4	3M2	MEK
4CA	V6-44	25.0	29	5.7	SC	THC	650	33.7	AB5	Stoddard Solvent A
5S	V6-81	27.2	28	5.2	SC	THC BNZ HXA	3820 16 830	220.9 1.0 48.0	AB1	Extra Unleaded Gasoline
10S	SC-81	27.2	25	5.0	SC	THC	1227	73.1	OS2	Gasoline Blend Stock
11PF	SC-83	25.0	19	3.7	SC	HXA	317	23.0	AB5	HXA
11PA	V6-45	26.7	14	2.8	SC	THC BNZ HXA	7514 3 3860	809.3 0.3 399.1	AB5	Gasoline Blend Stock
11SF	V6-47	24.4	43	8.5	SC	XLP	1888	51.6	AB4	XLP

* SC - small charcoal (100/50)

TABLE VIII.4 AREA SAMPLES TAKEN DURING LOADING OPERATIONS

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)	Concentration (ppm)	Area
H-39	20.0	436	86.8	LC	HXA THC XLP	135 1169 194	0.4 3.6 0.5	Cargo Control Room
08-P9	20.0	306	60.9	LC	HPT THC XLP	50 1178 14	0.2 5.2 0.1	Cargo Control Room

* LC - large charcoal (400/200)

TABLE VIII.5. SUMMARY OF NOISE DATA TAKEN DURING PRODUCT LOADING

Sample Number	Worker	Duration (min)	Activity	Noise Source	Max. Sound Pressure Level over 2 Minute Period (db(A))	Cumulative Exp. Over Monitoring Period (db(A))
18	3M2	23	Tank Top Off	Vent Popoffs (1 product loading)	84	82.3
27	AB6	238	Loading moni- toring and tank top off	Vent Popoffs (11 products loading)	95	82.7
28	PM2	472	Loading moni- toring and tank process-	Vent Popoffs (13 products loading), Cargo Pump	101	86.3
29	3M2	180	Loading moni- toring and tank top off	Vent Popoffs (11 products loading)	90	82.6
30	AB1	170	Loading moni- toring and tank top off	Vent Popoffs (7 products loading)	100	87.8

<u>Protective Equipment</u>

Chemical resistant gloves were occasionally worn by the ABs and OS during hose handling activities.

IX. Miscellaneous Activities/Samples

Besides the activities already discussed, three additional activities were also monitored during this voyage. Vapor monitoring was performed during deck cleaning with a degreaser. The material safety data sheet for the degreaser was provided by the manufacturer. Based on this data sheet, the compound for analysis was total hydrocarbon. The occupational exposure sample taken during the deck cleaning, V6-36 is summarized in Table IX.1.

During the voyage between two of the discharge ports, an intraship transfer of XLP took place. The purpose of this transfer was to eliminate the need for a jumper hose at the next discharge terminal. Sample V6-14 was taken on a pumpman during this activity.

Samples FT-8 and FT-13 were collected near the starboard, port, aft diesel and fuel oil vents, respectively, and the results are summarized in Table IX.1. The port side sample was set up to collect diesel fuel vapors that were evolving from residue in a drip pan beneath the diesel vent. The sampling location was downwind (to stern) of the diesel vent. The starboard area sample was located at the fuel oil vent to collect bunker fuel vapors. These non-breathing zone area samples were motivated by the persistent odor of the respective liquids,although odor is no indication of a potential health hazard.

Noise sample 5 was taken on the 2M while he was tending mooring lines on the poop deck during docking. The noise source was the DHA bleed during depressurization of the DHA system. The data from this sample are shown in Figures IX.1 and IX.2. The maximum sound pressure level over a two-minute period was 99 db(A). The cumulative effective exposure over the monitoring period was 87.1 db(A).

TABLE IX.1. MISCELLANEOUS SAMPLES

Sample Number	T (°C)	Duration (min)	Volume (L)	Sorbent*	Chemical	W_c(μg)+	Concentration (ppm)+	Personnel/Area
V6-36	26.5	132	26.5	SC	THC	54	0.6	AB6 (Deck Cleaning)
V6-14	21.1	58	11.72	SC	XLP	407	7.9	PM2 (Intraship Transfer)
FT-8	28.3	320	64.3	LC	THC	23,900	102.5	Starboard aft fuel oil vent source
FT-13	28.3	334	66.5	LC	THC HXA	34,072 3,260	141.3 13.5	Port aft fuel oil vent source

* SC - small charcoal (100/50)
LC - large charcoal (400/200)
\+ ND - not detectable

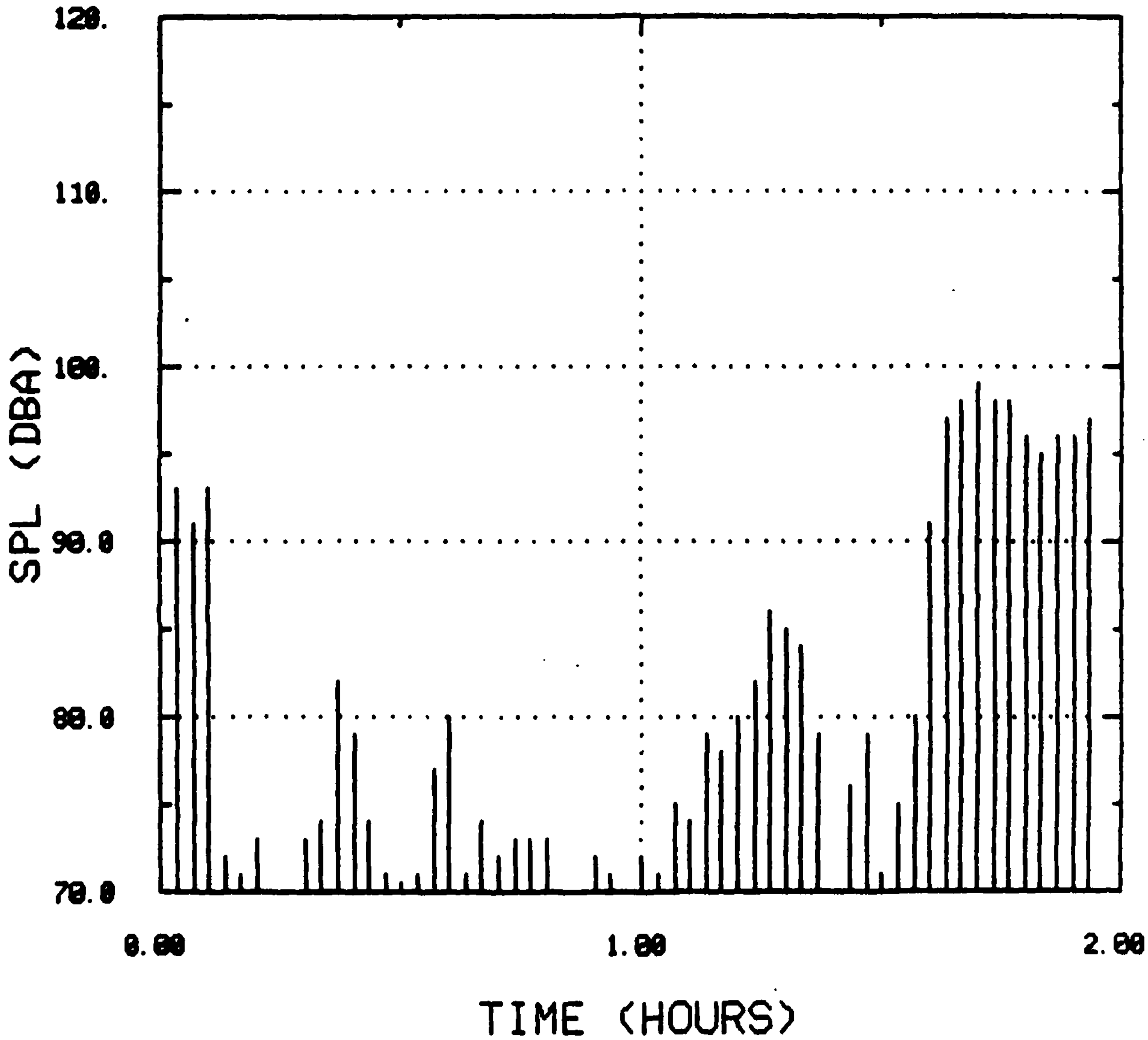


FIGURE IX.1. NOISE DOSIMETRY - SAMPLE 5

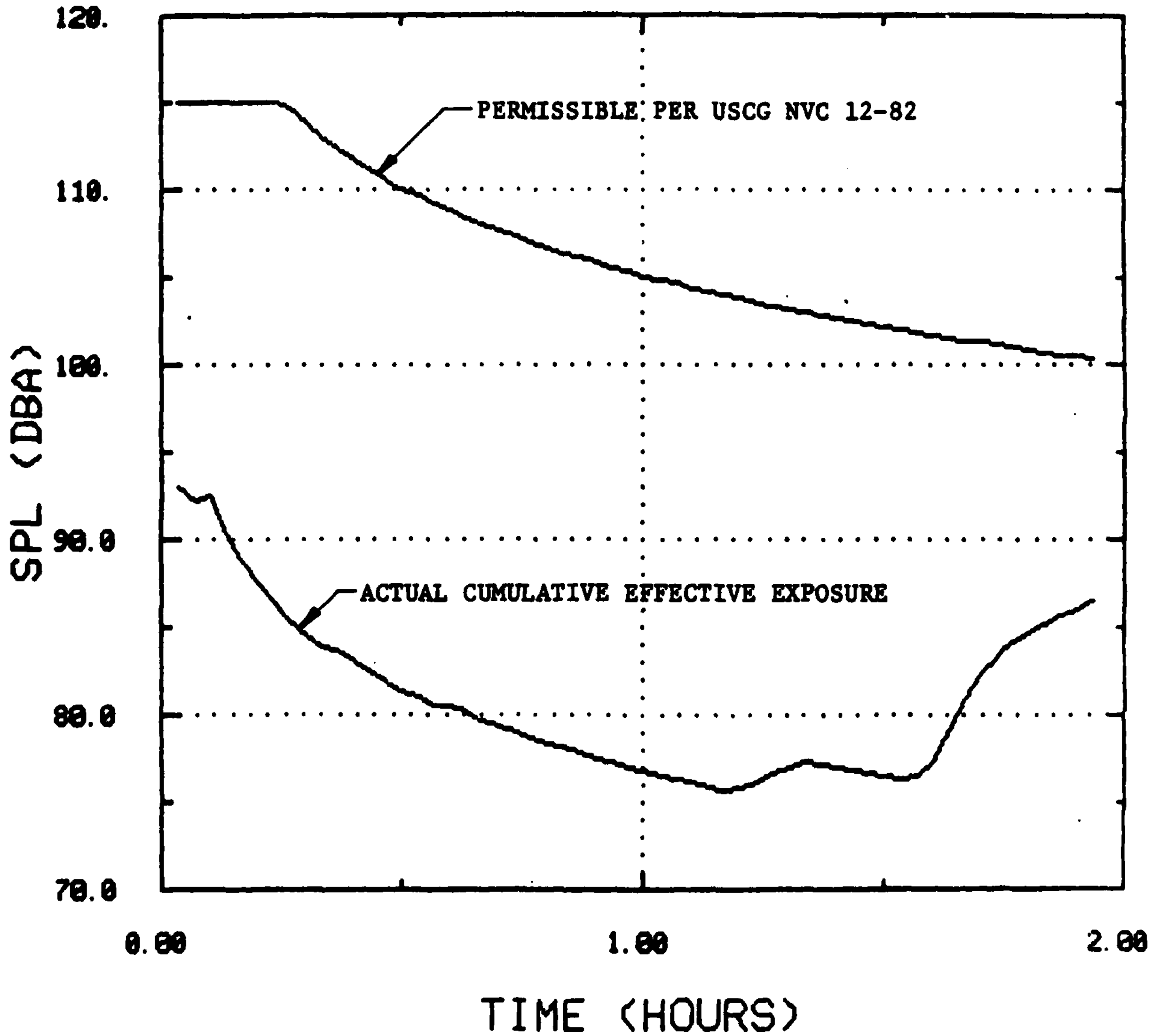
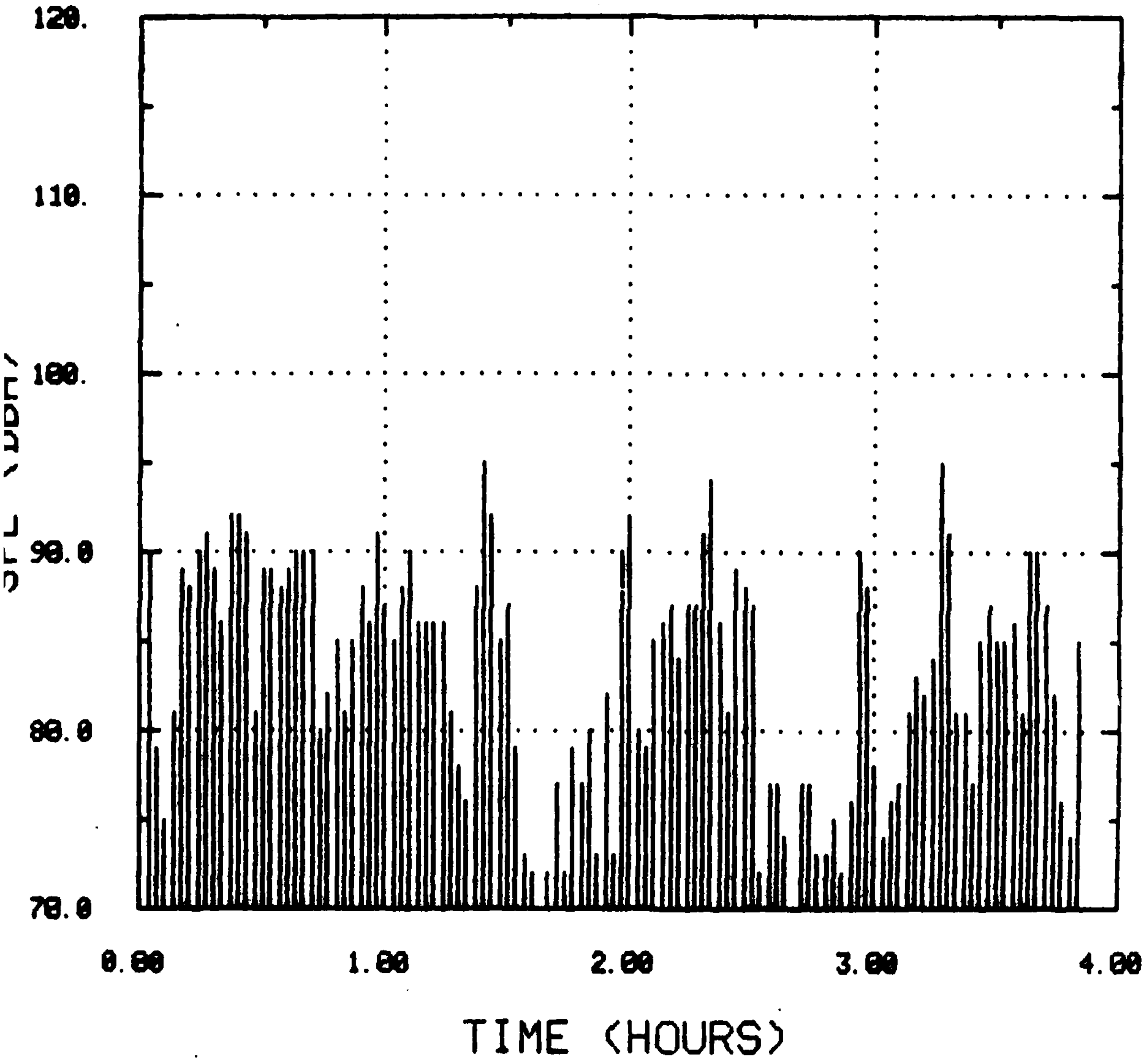


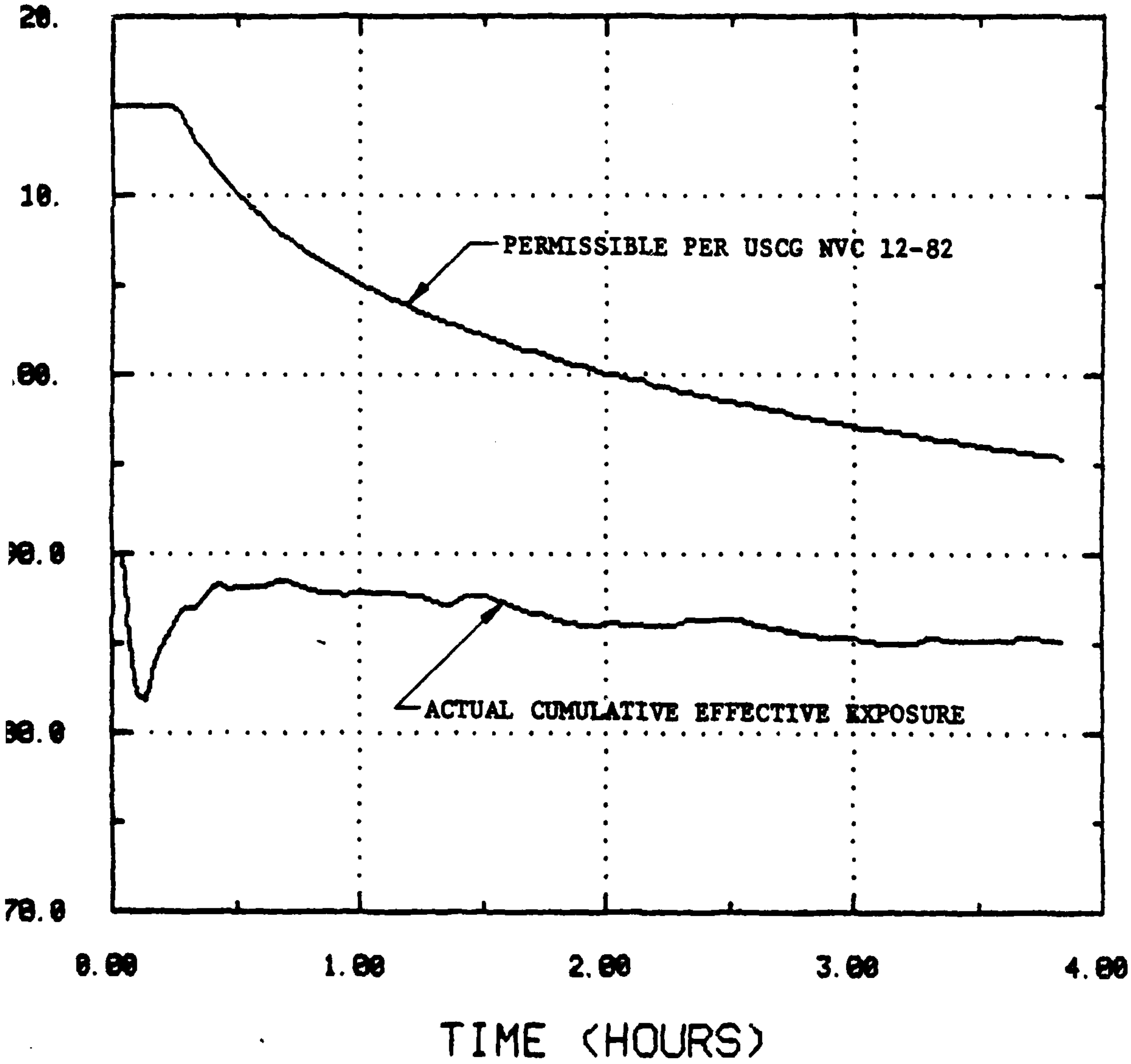
FIGURE IX.2. CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 5

APPENDIX F-1

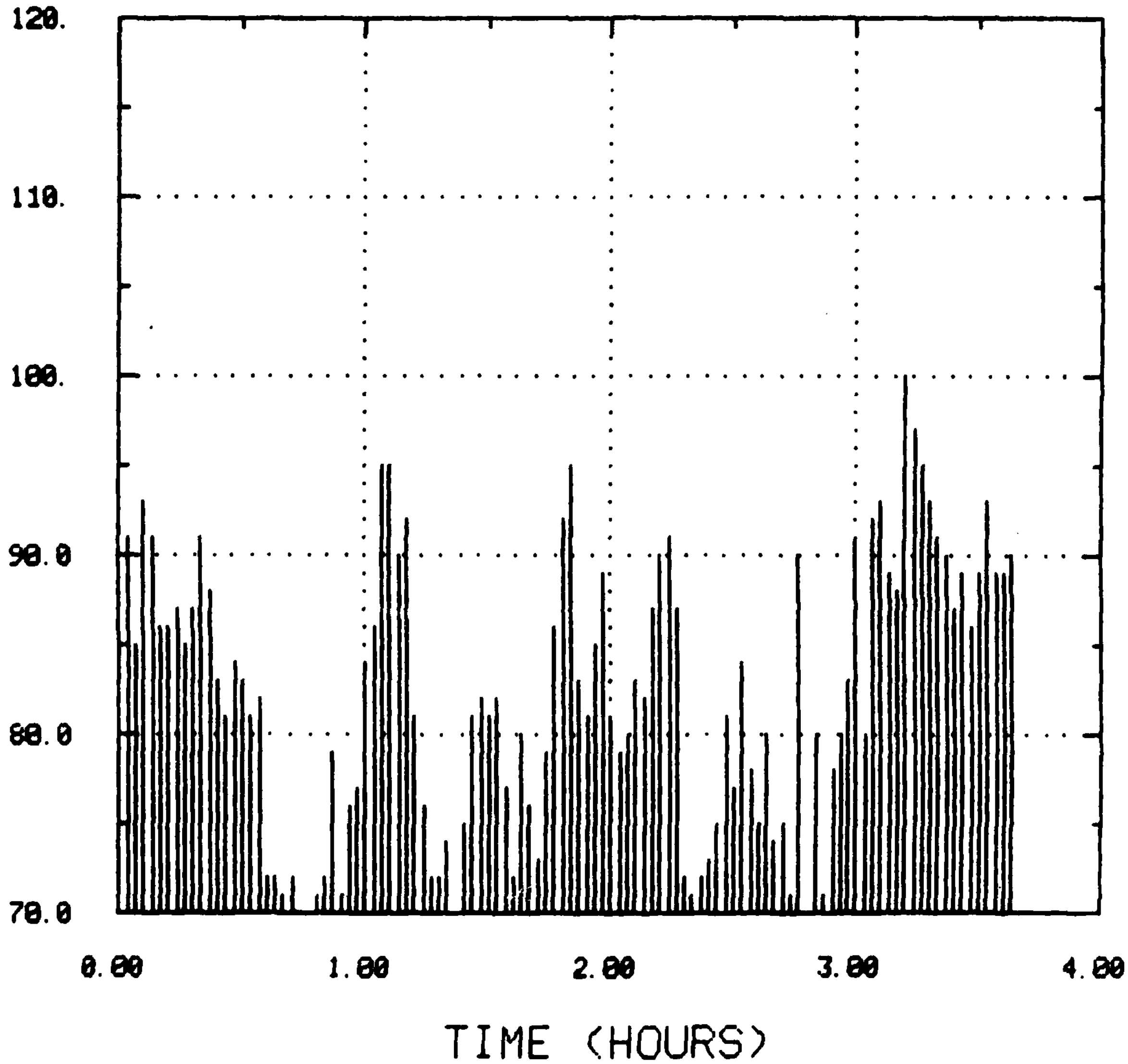
NOISE DOSIMETRY DURING PRODUCT DISCHARGING



NOISE DOSIMETRY - SAMPLE 1



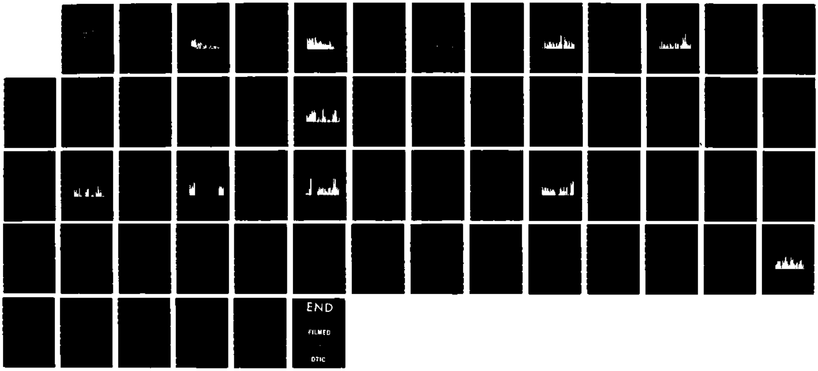
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 1

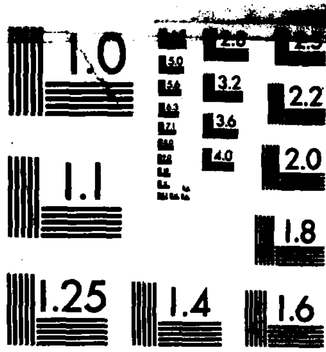


NOISE DOSIMETRY - SAMPLE 2

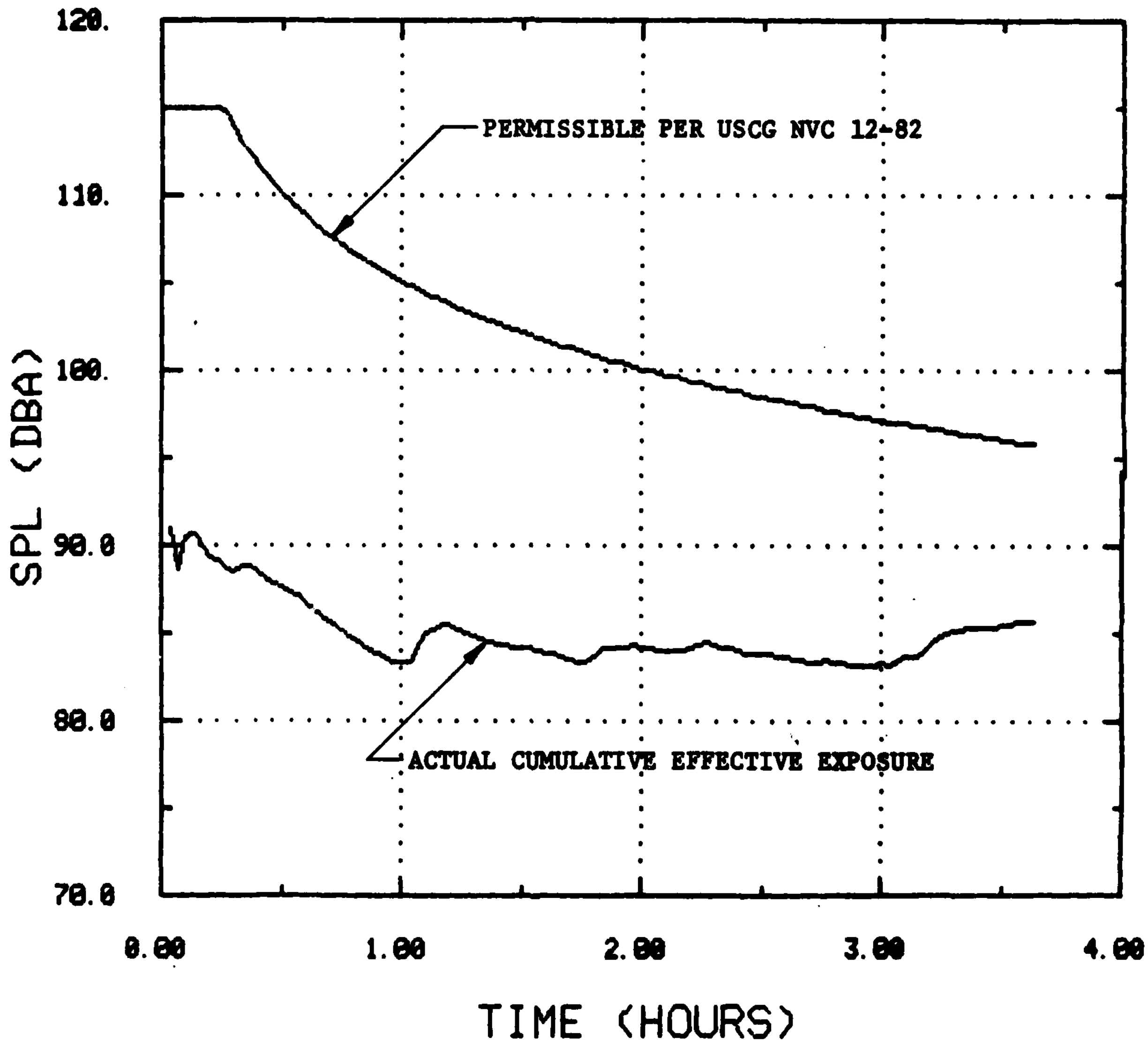
AD-A157 308 A CREW EXPOSURE STUDY PHASE II VOLUME 2 AT SEA PART B (U) SOUTHWEST RESEARCH INST SAN ANTONIO TX DIV OF ENGINEERING AND.. W J ASTLEFORD ET AL. APR 85 5/5

UNCLASSIFIED USCG-D-12-85 DTCG23-80-C-20015 F/G 6/10 NL

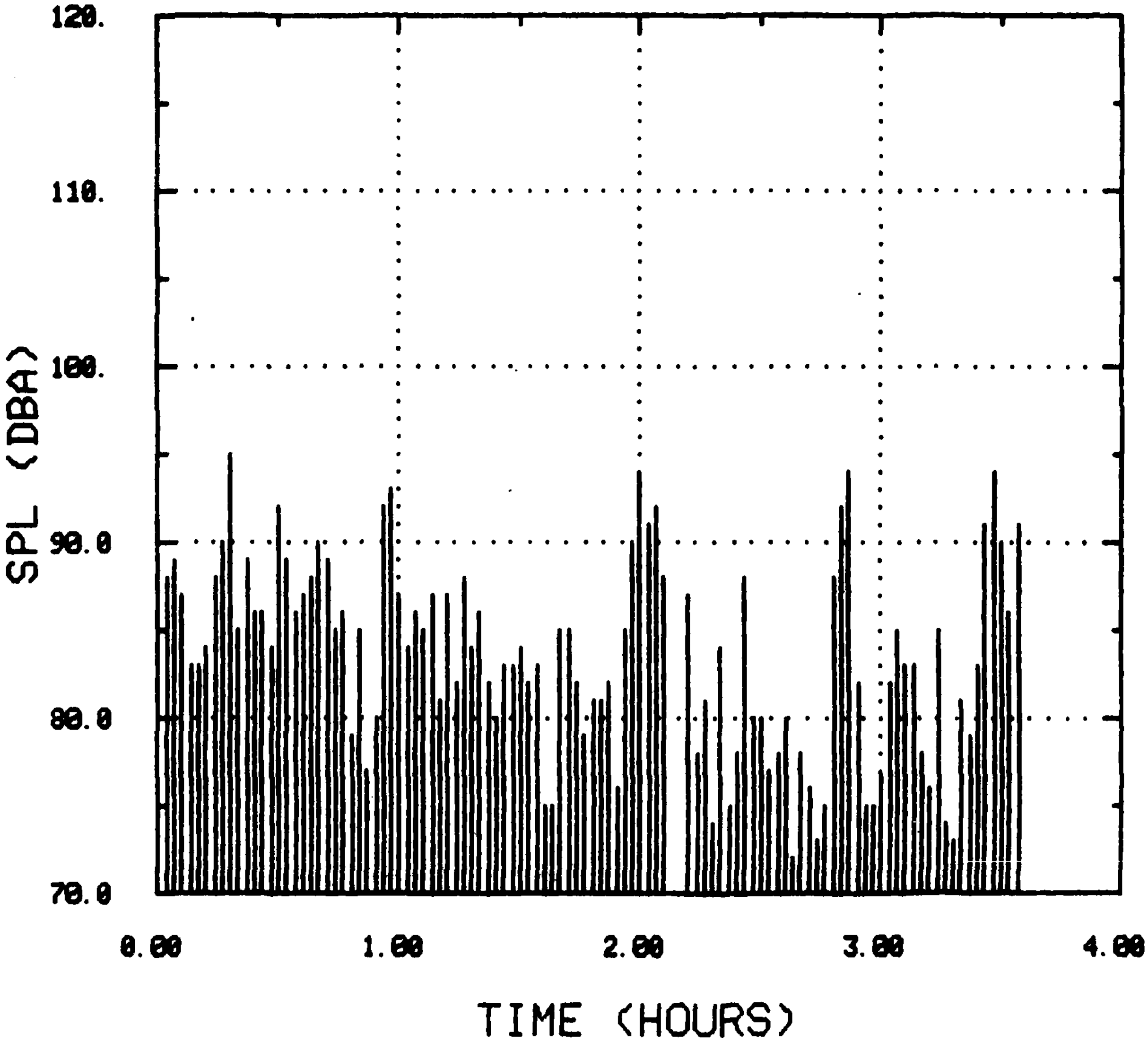




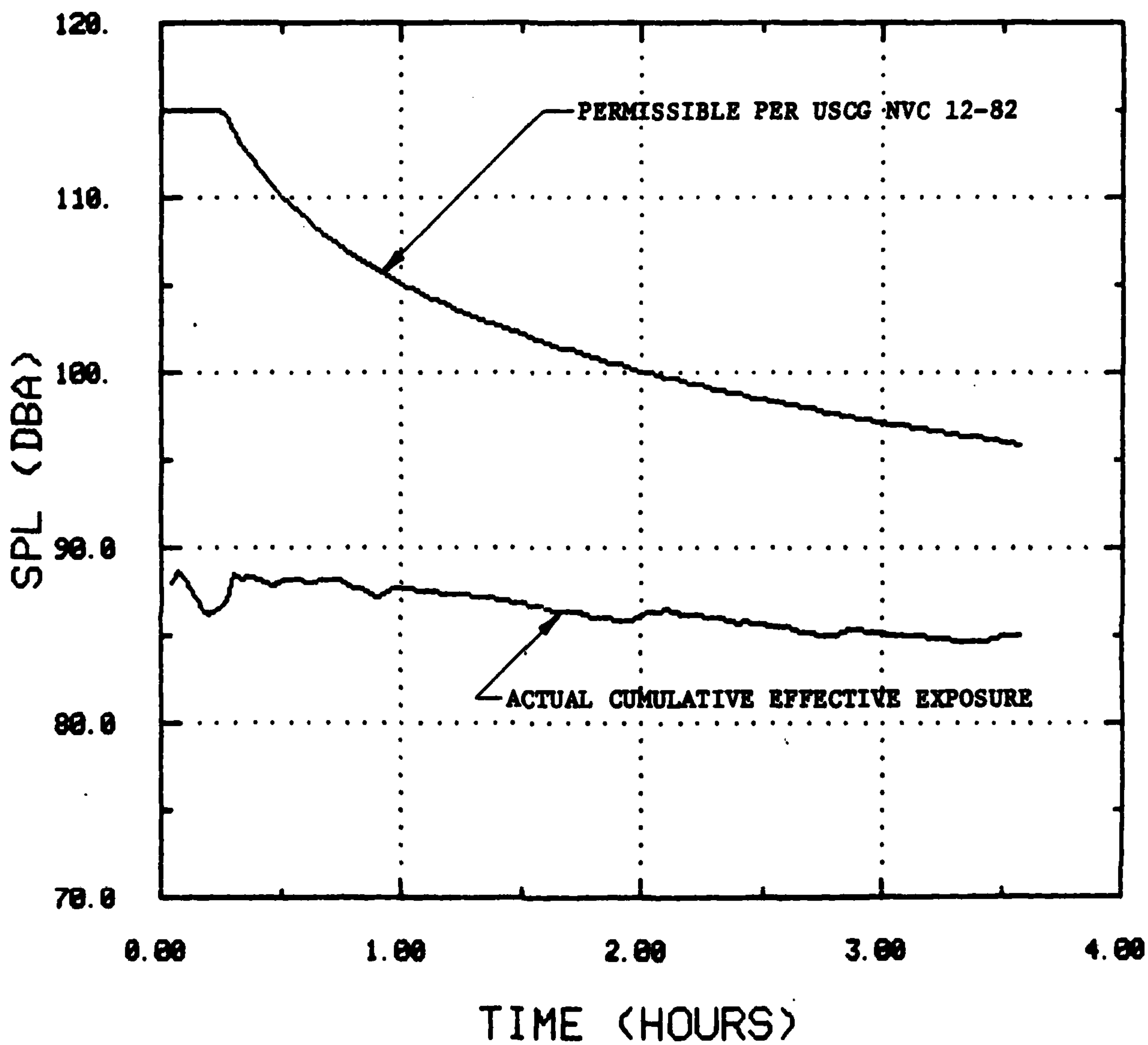
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



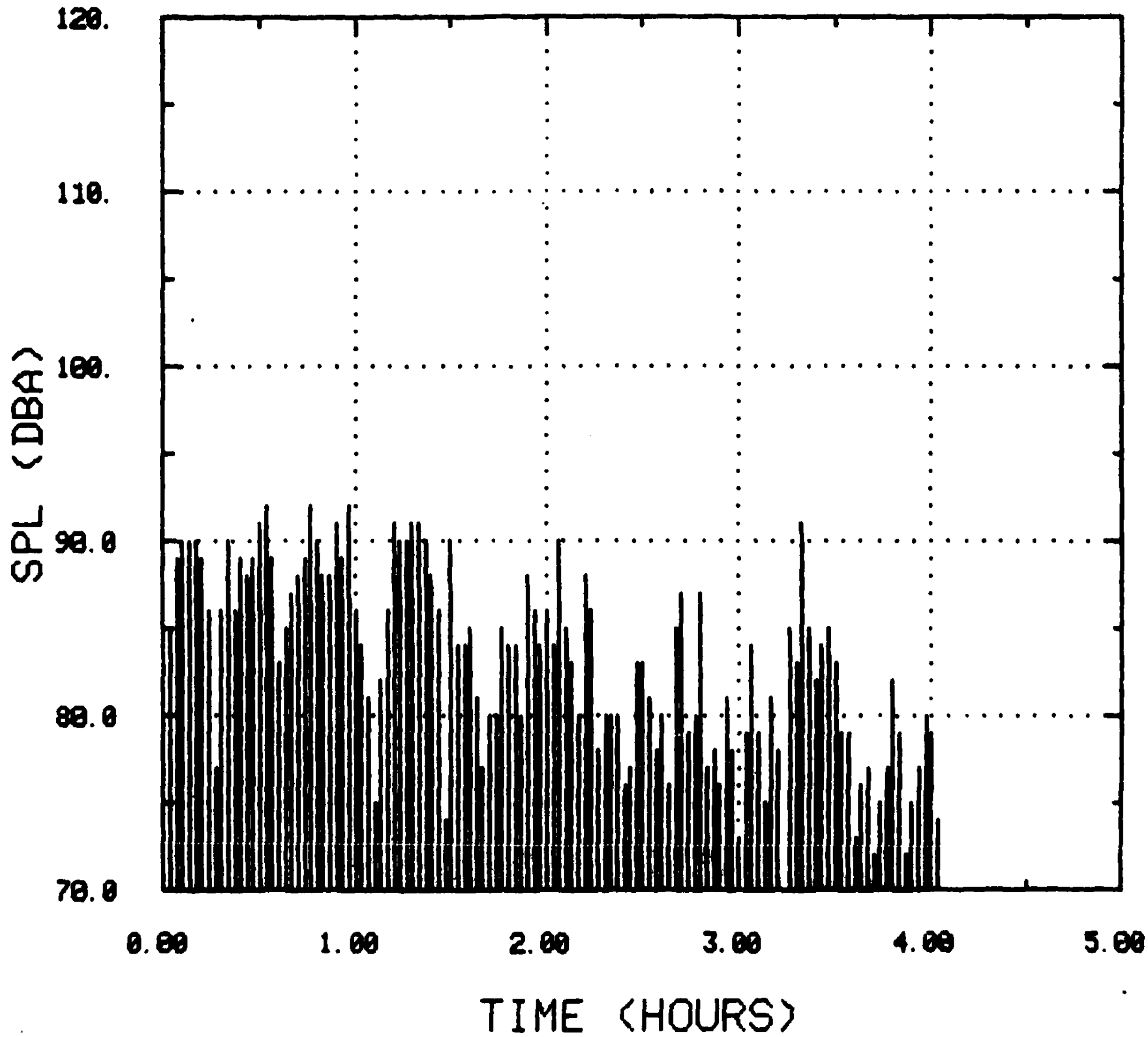
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 2



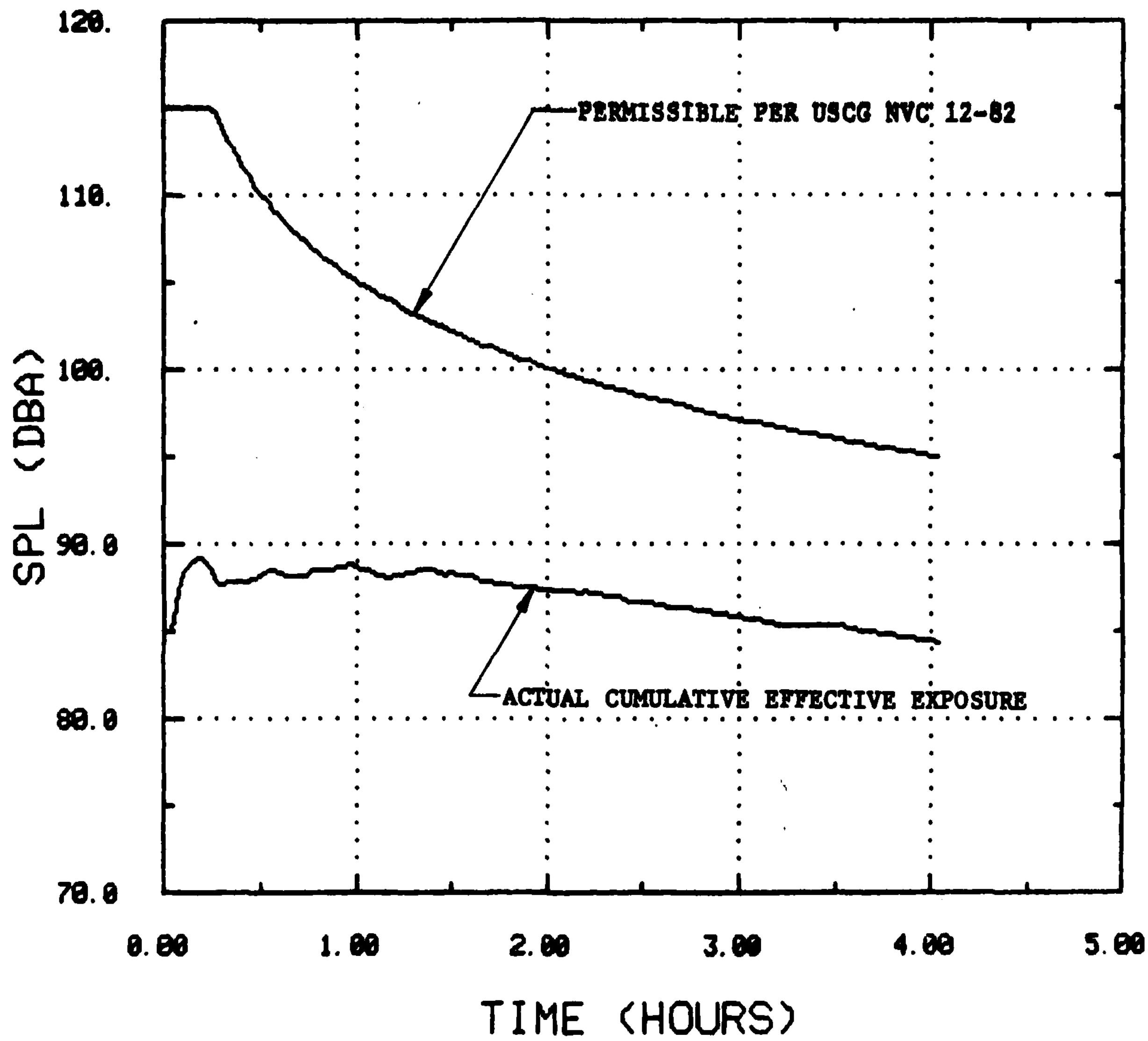
NOISE DOSIMETRY - SAMPLE 3



CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 3



NOISE DOSIMETRY - SAMPLE 4



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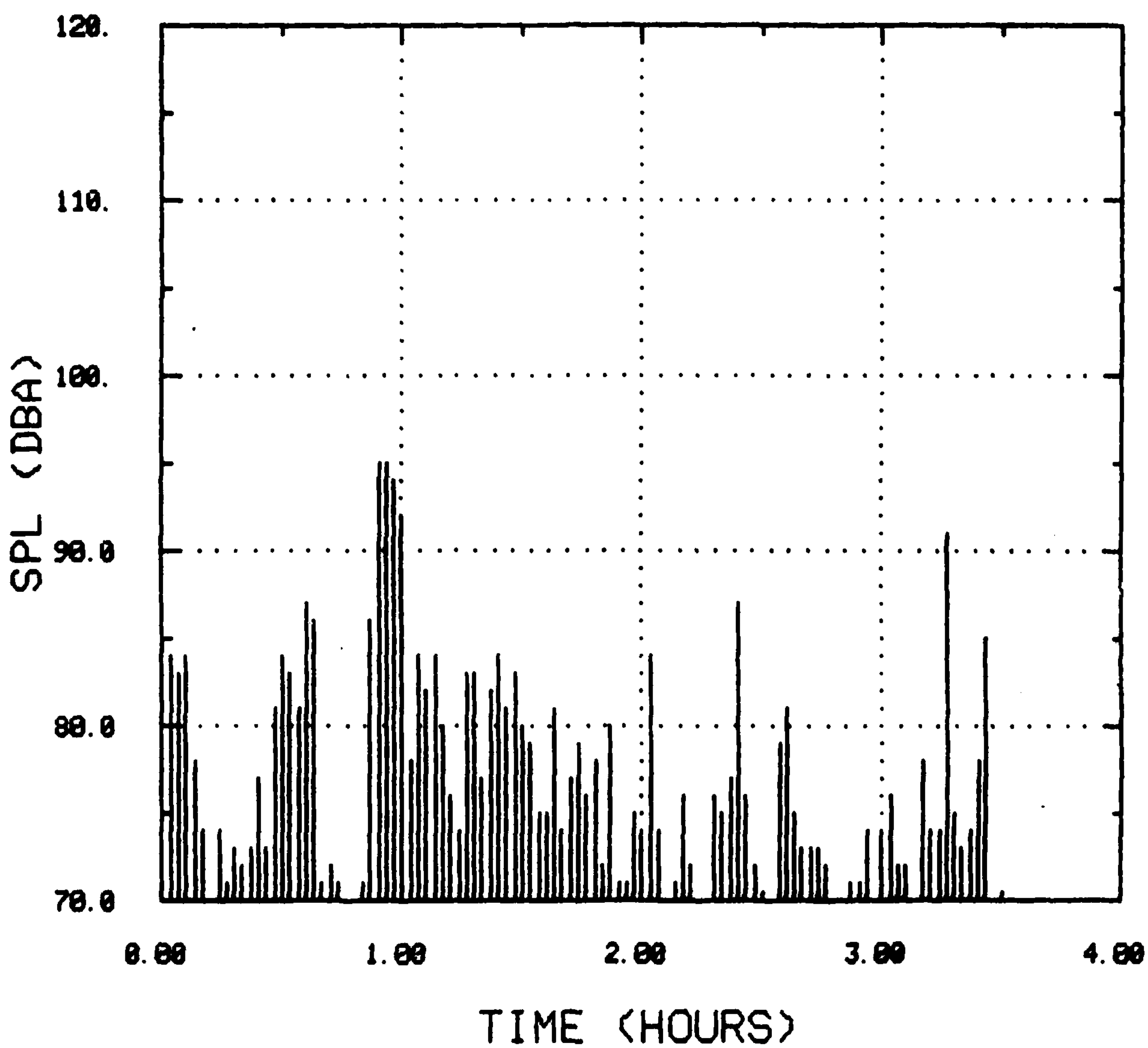
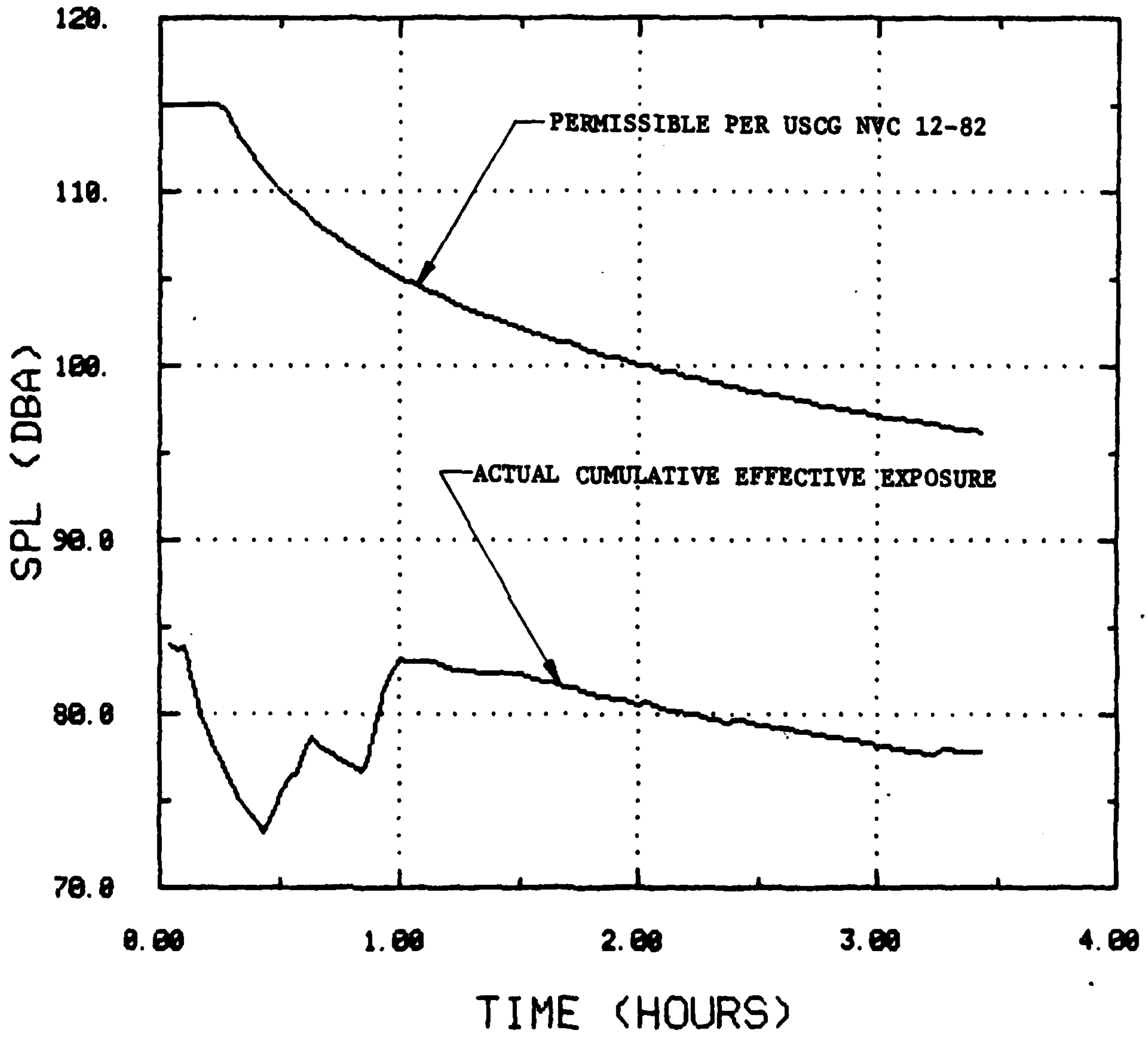
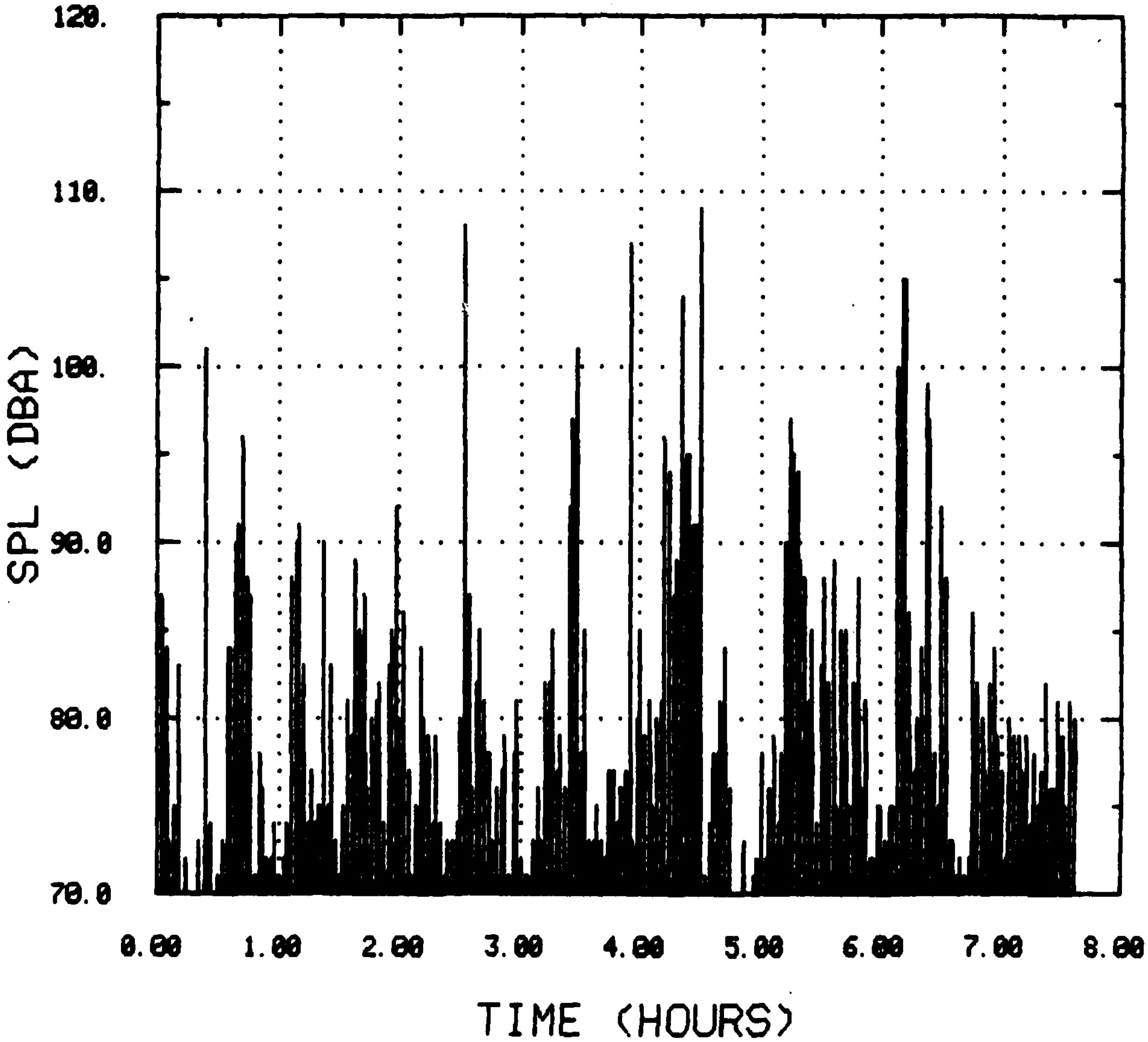


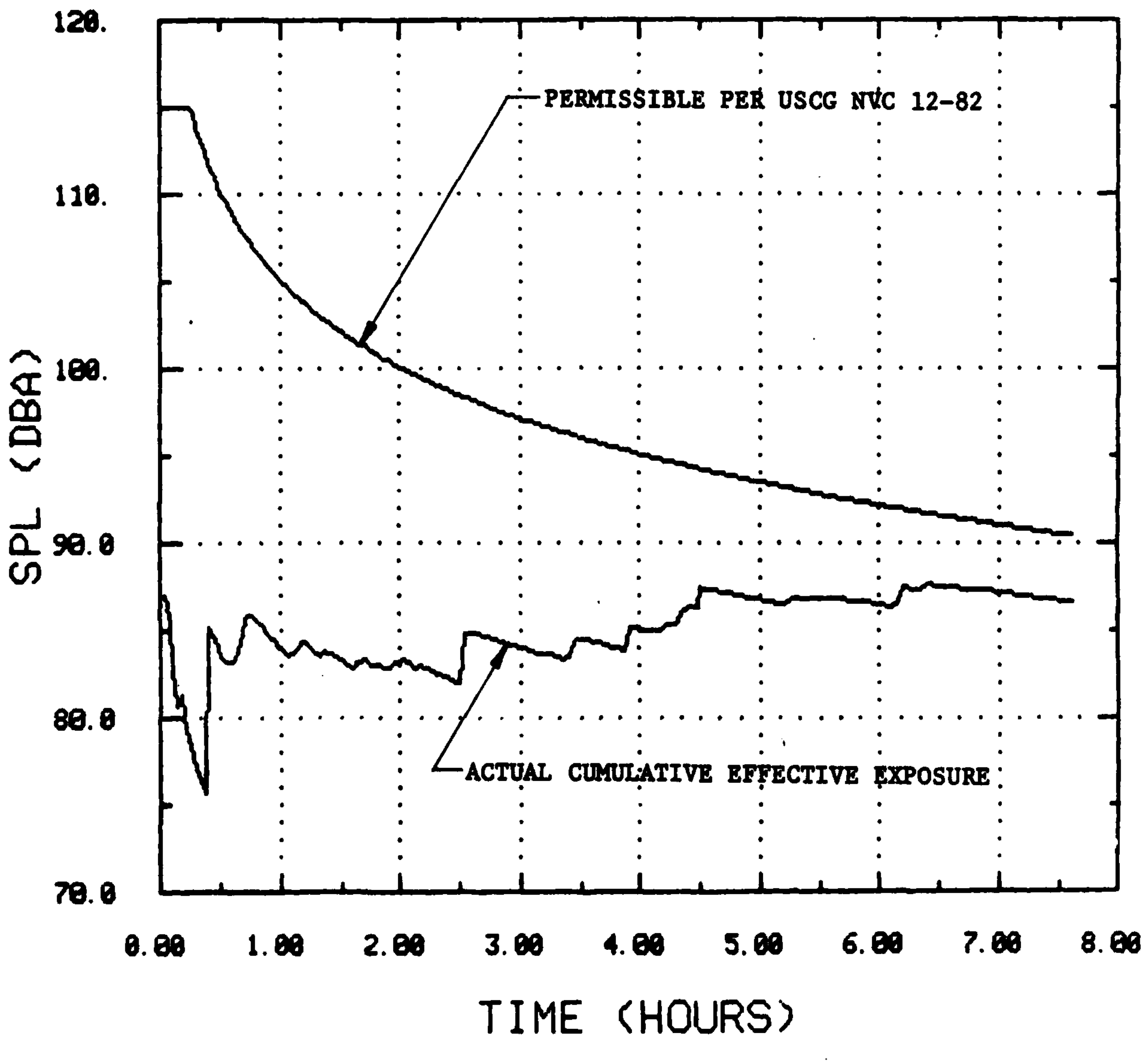
NOISE DOSIMETRY - SAMPLE 6



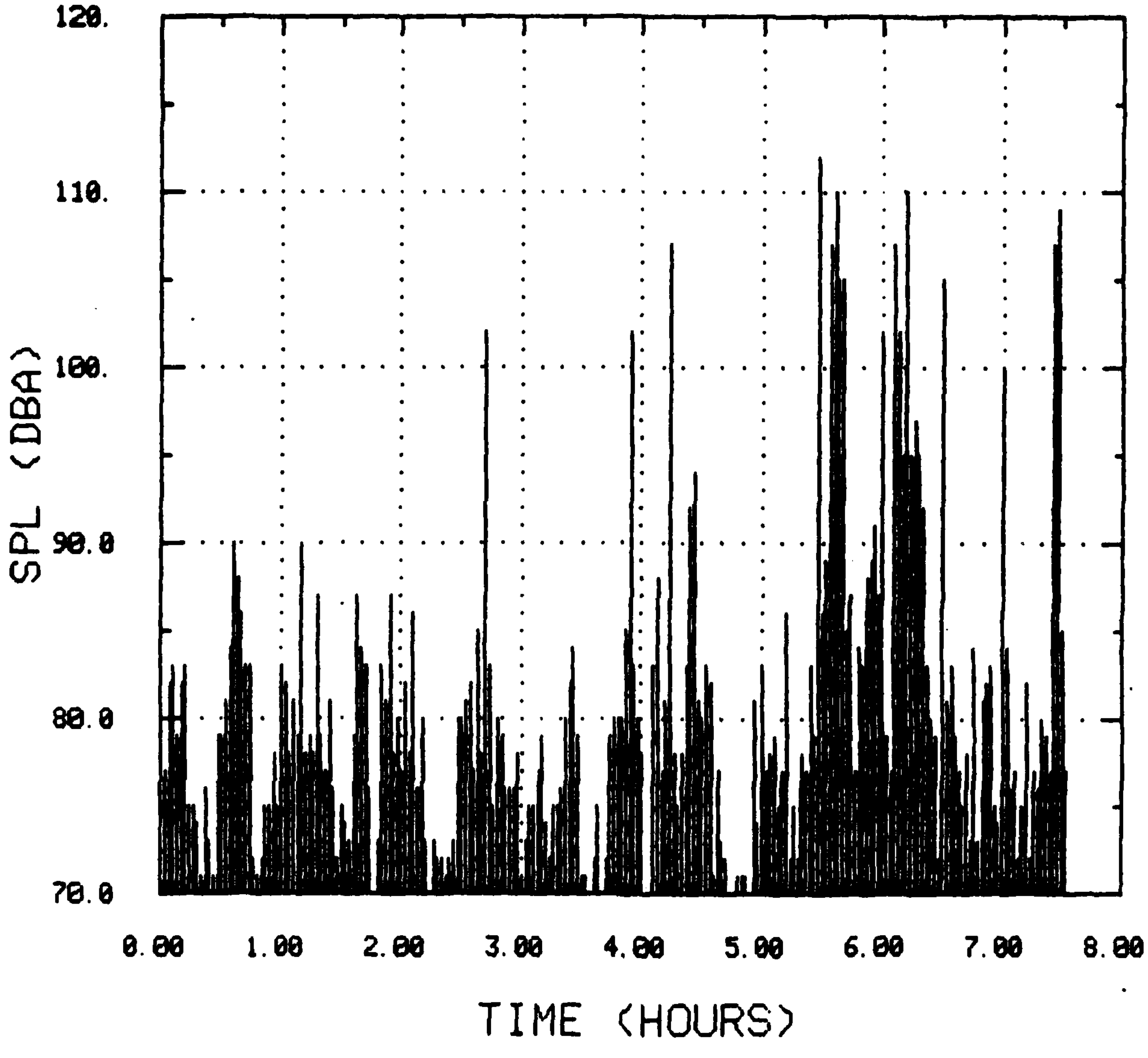
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 6



NOISE DOSIMETRY - SAMPLE 7



CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 7



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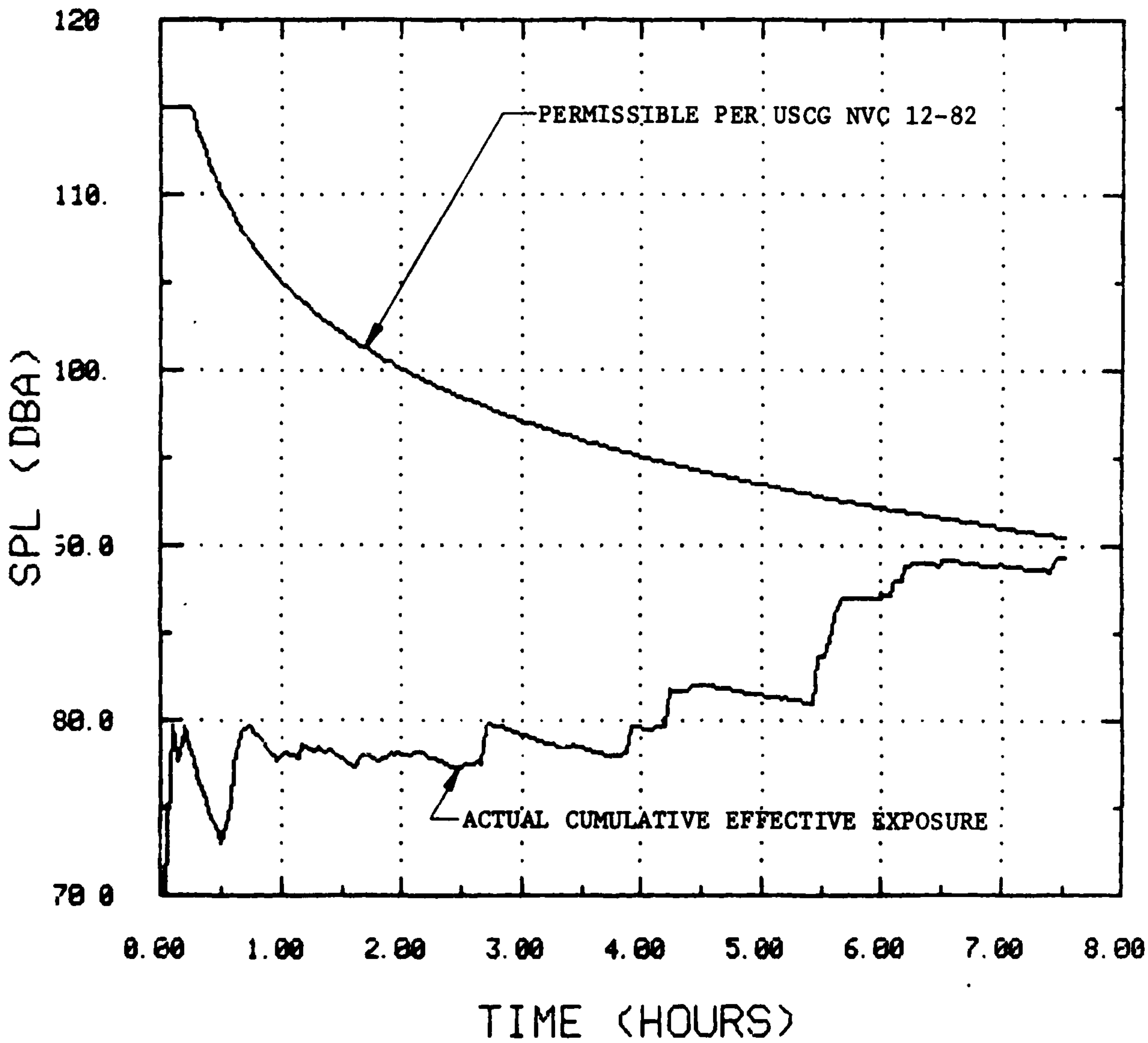
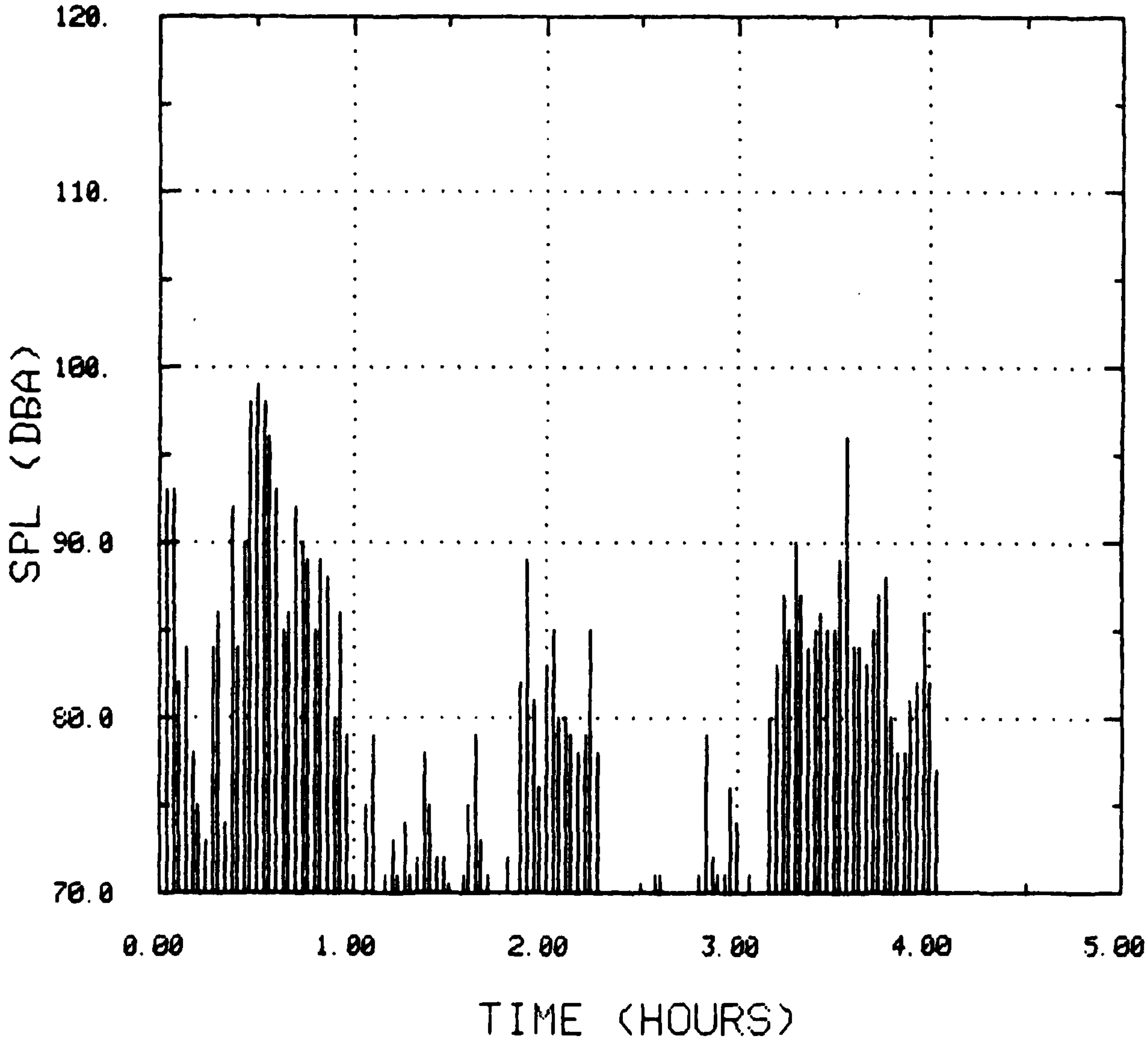
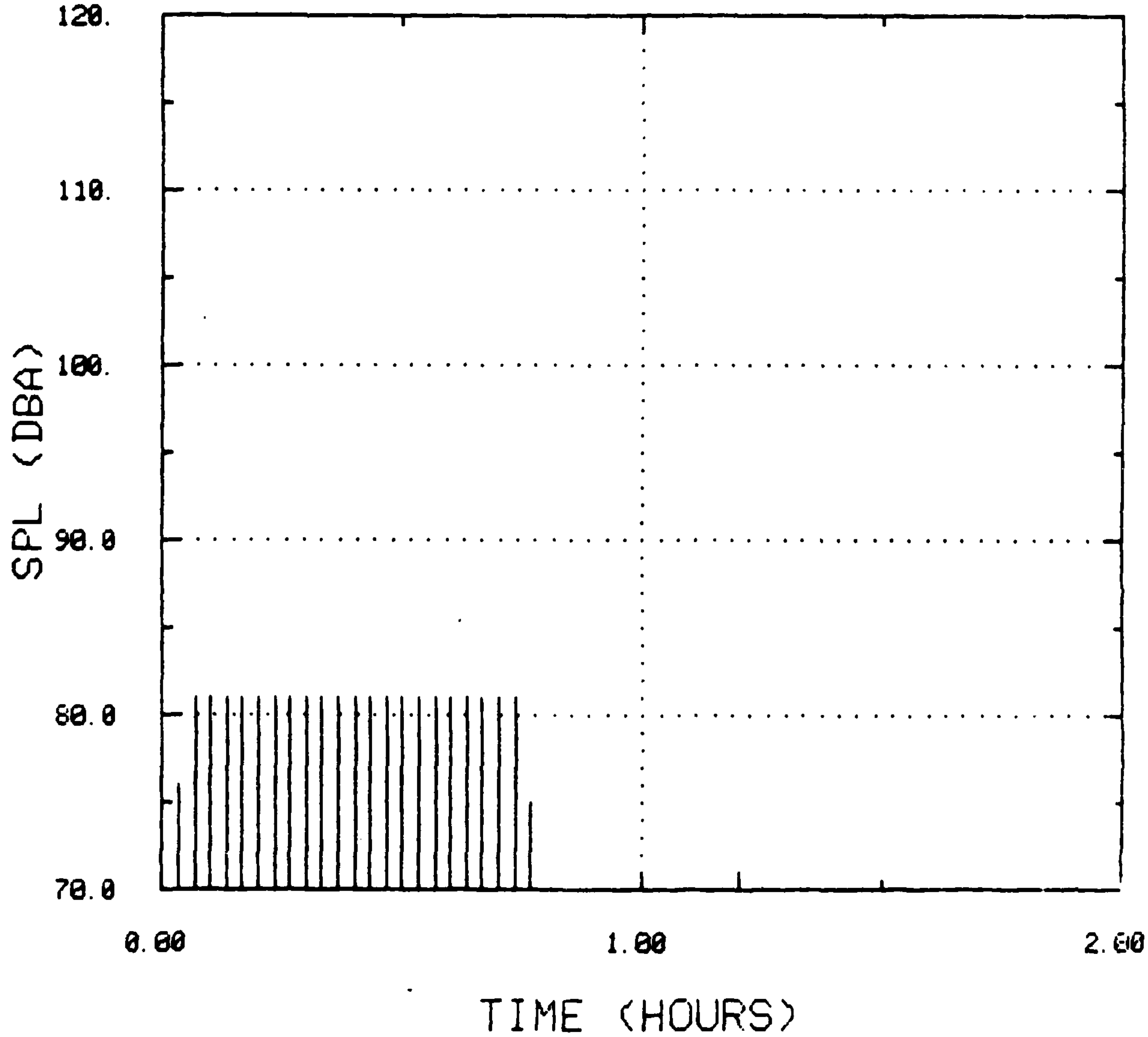


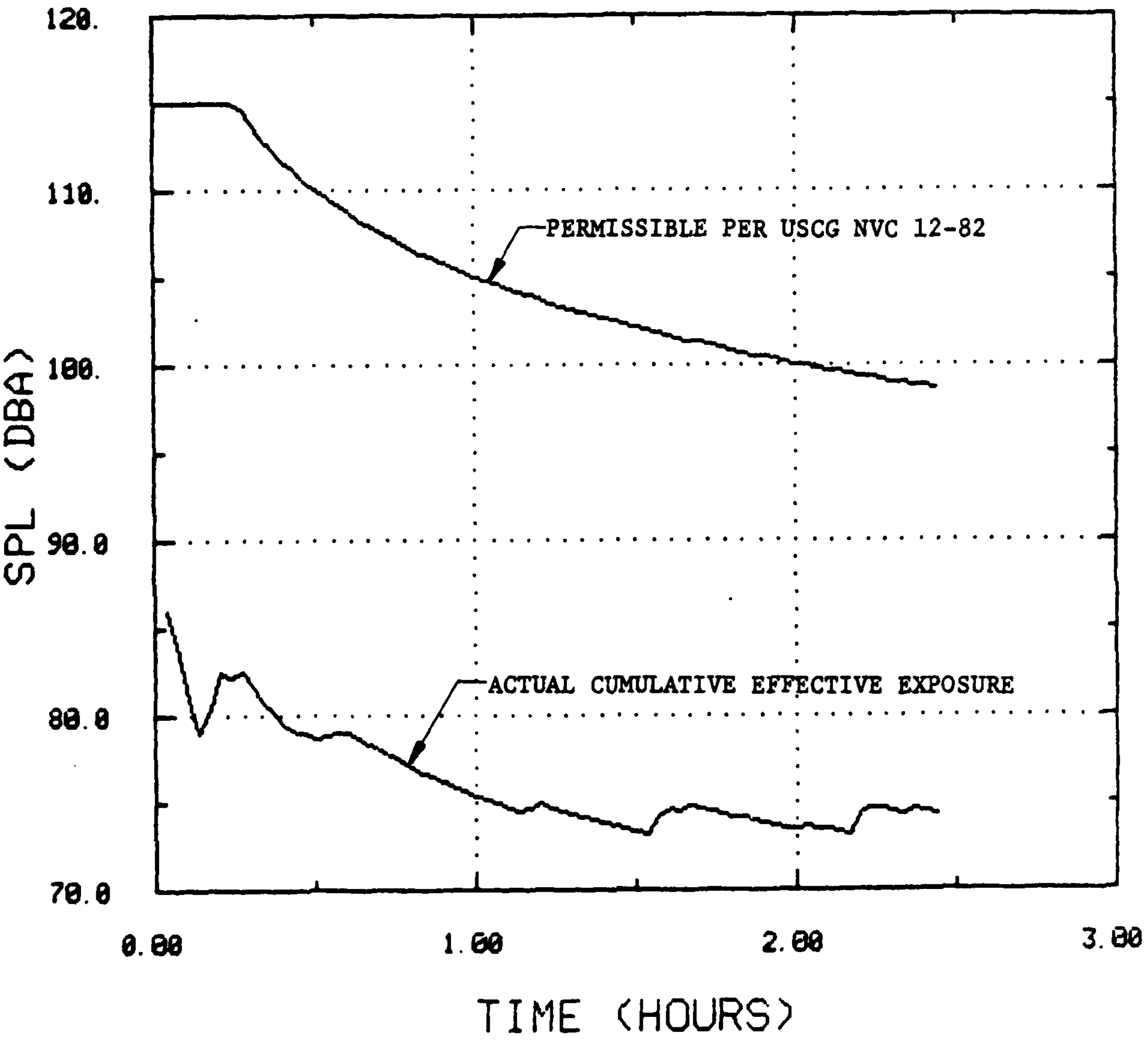
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 8



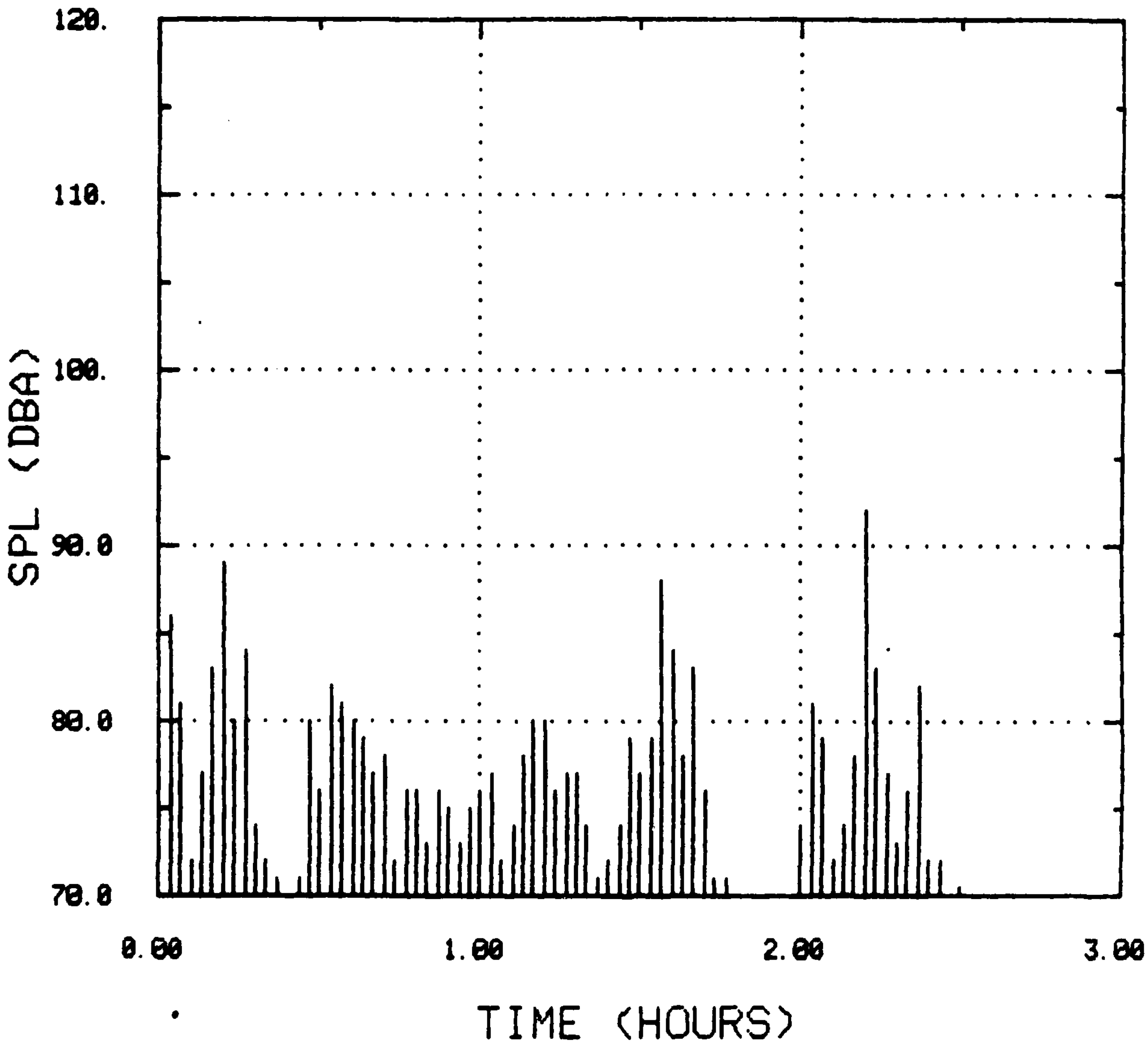
NOISE DOSIMETRY - SAMPLE 9



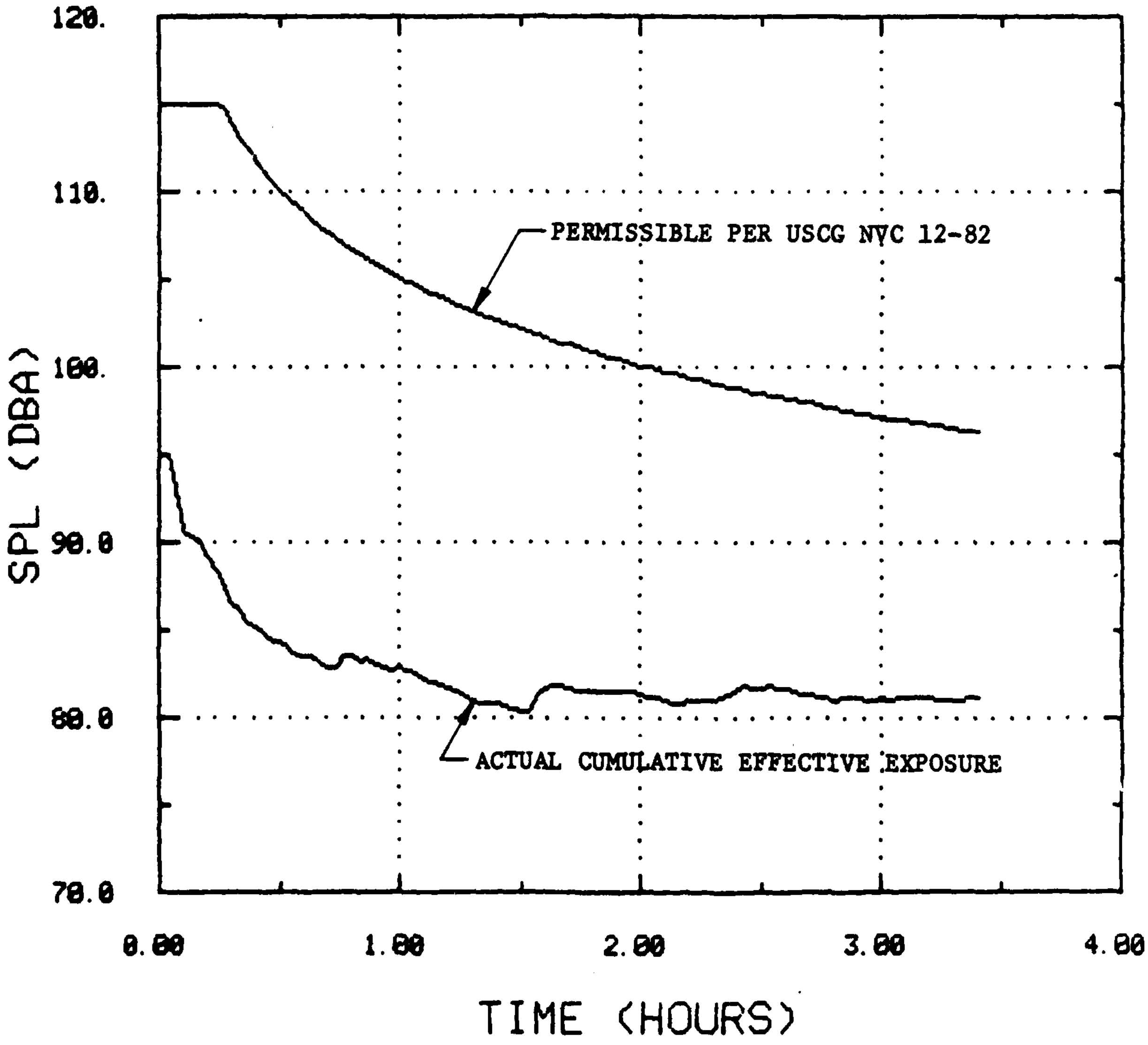
NOISE DOSIMETRY - SAMPLE 19



CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 16



NOISE DOSIMETRY - SAMPLE 16



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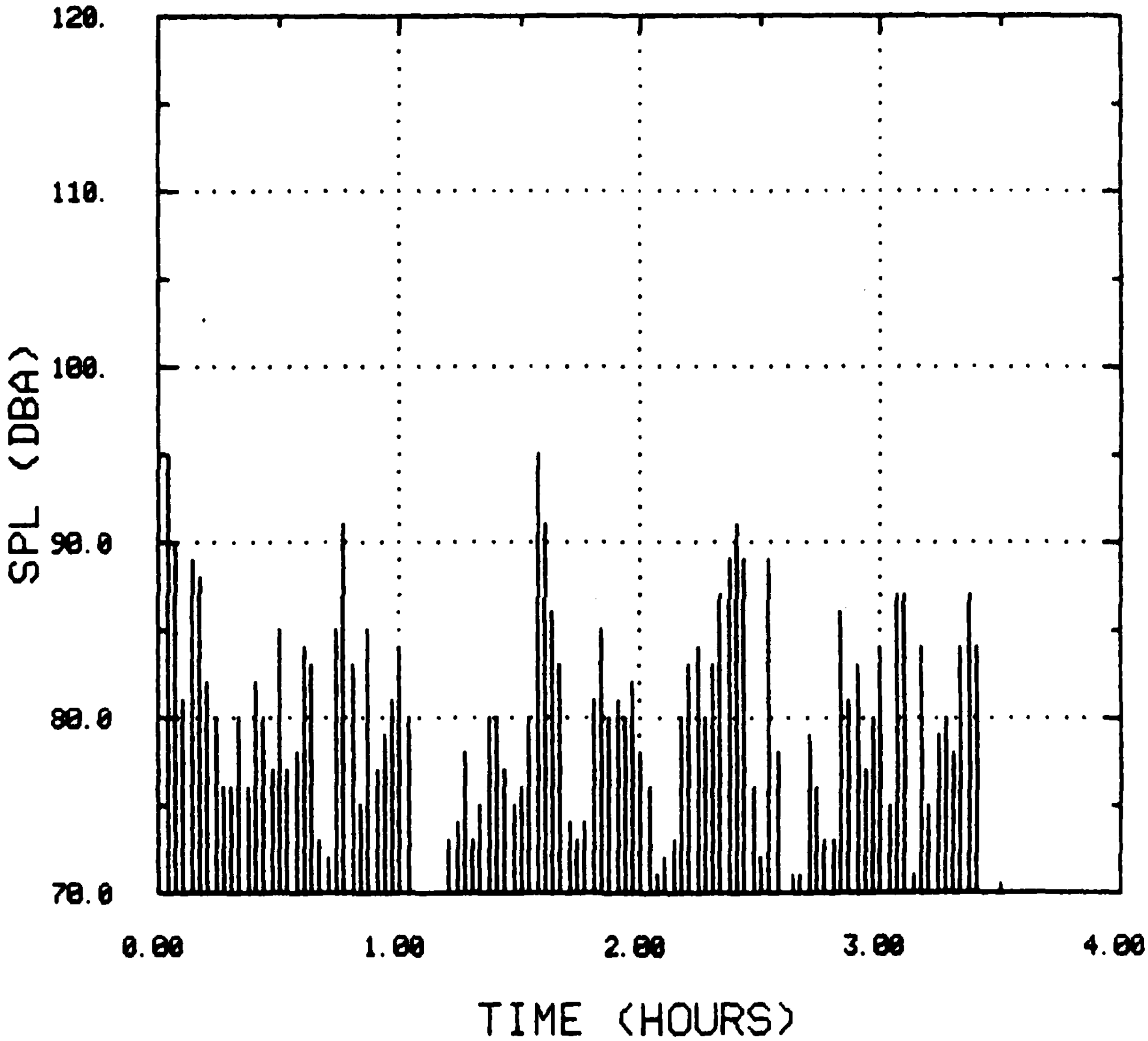
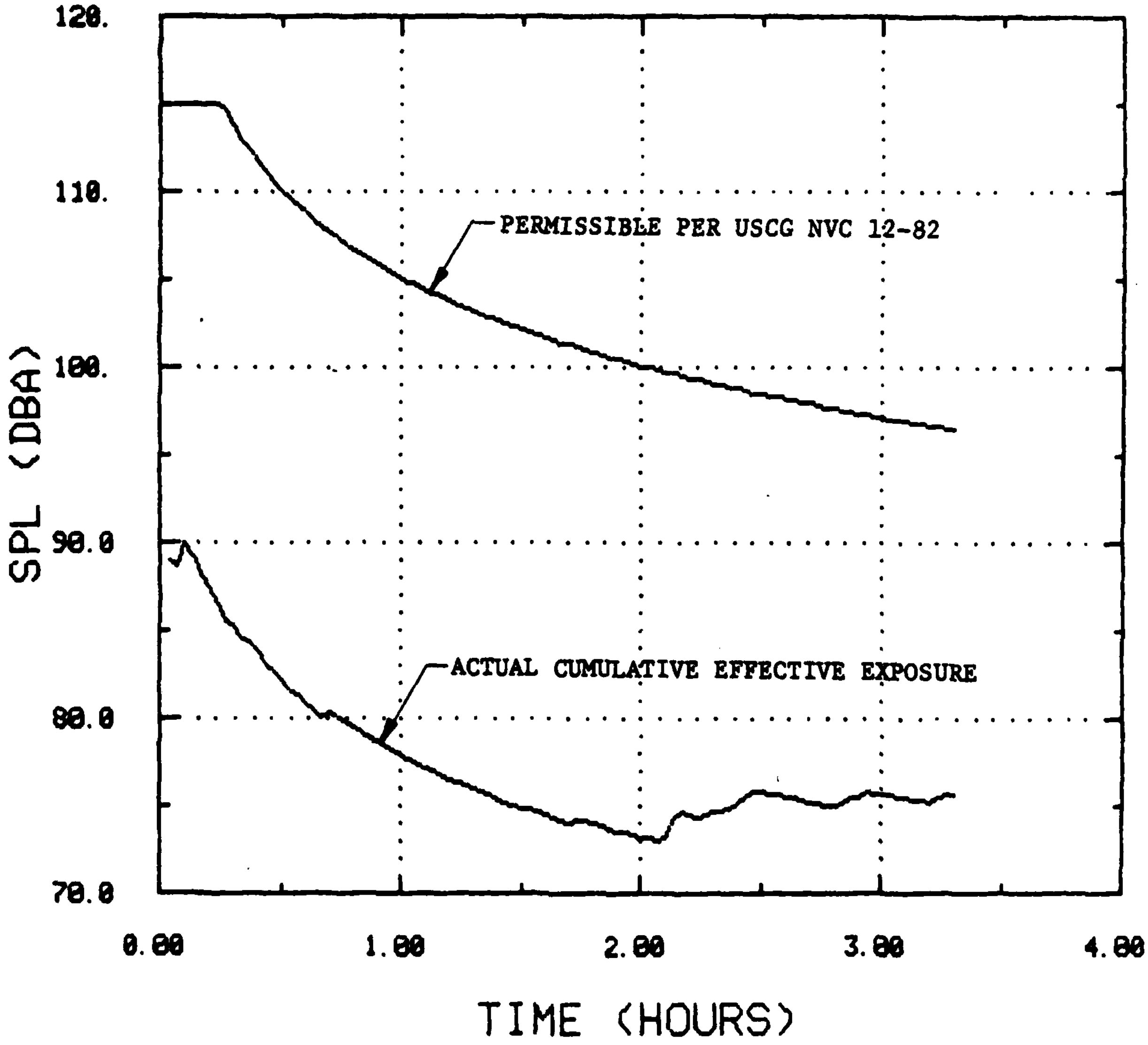
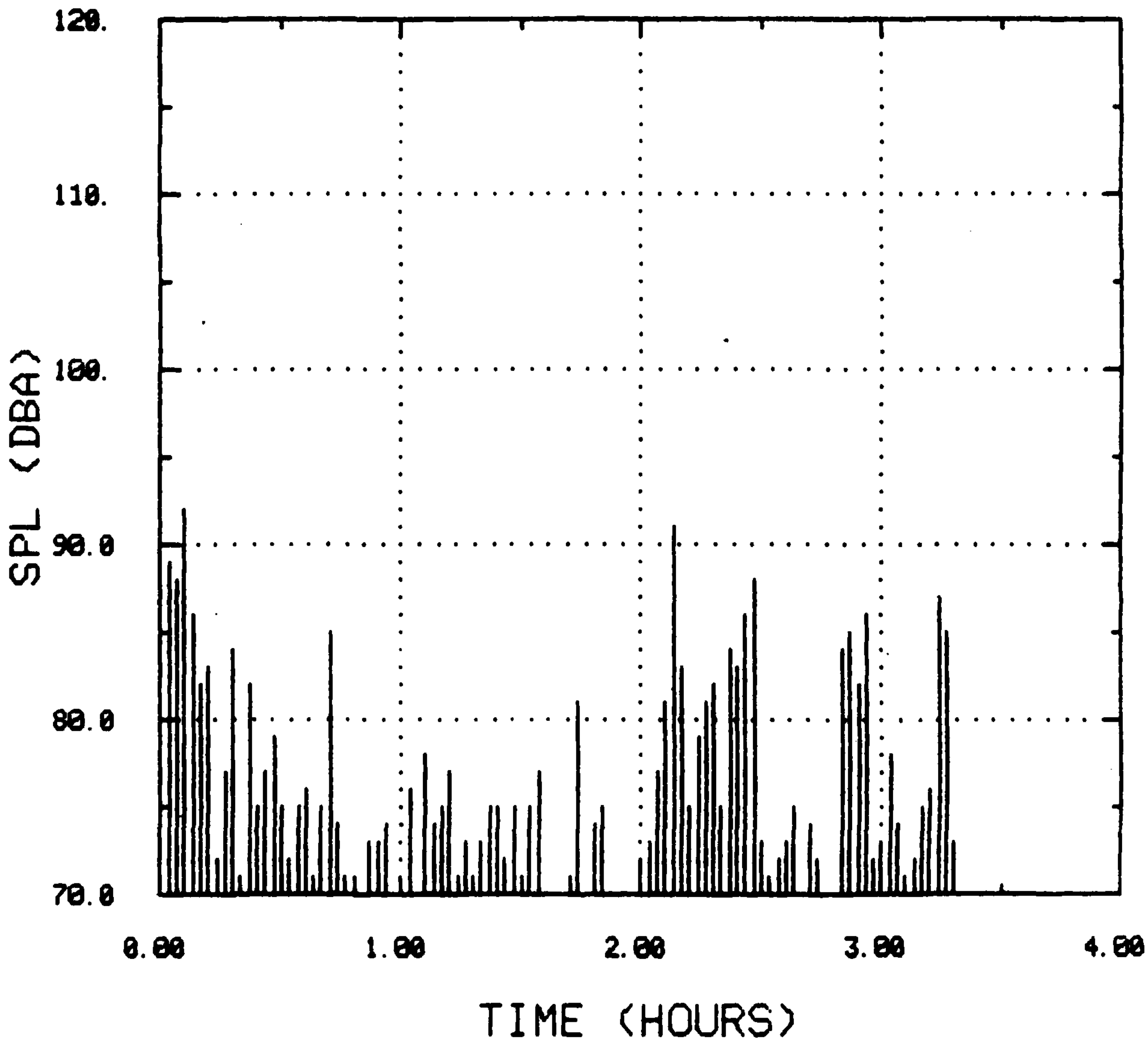


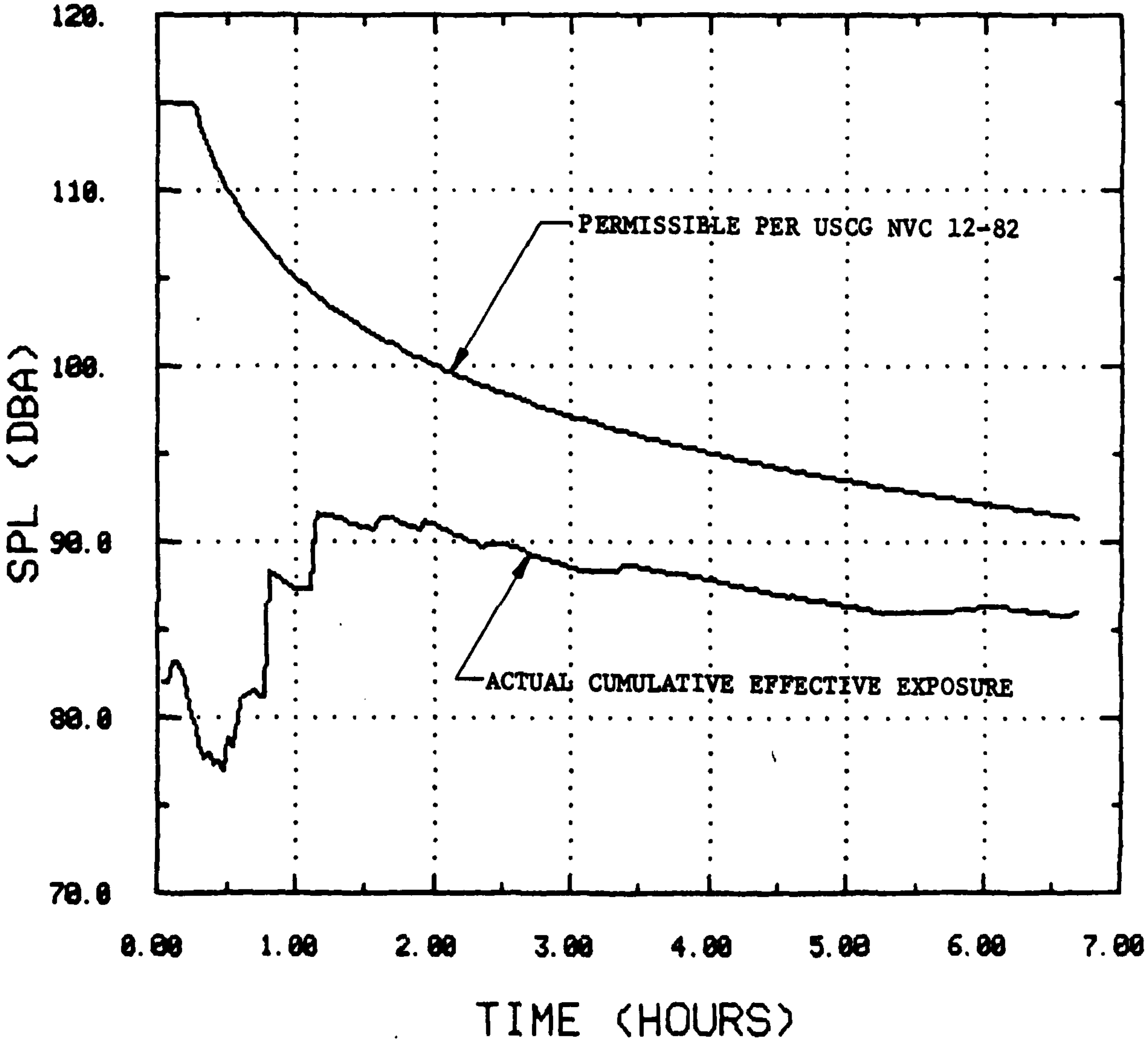
NOISE DOSIMETRY - SAMPLE 14



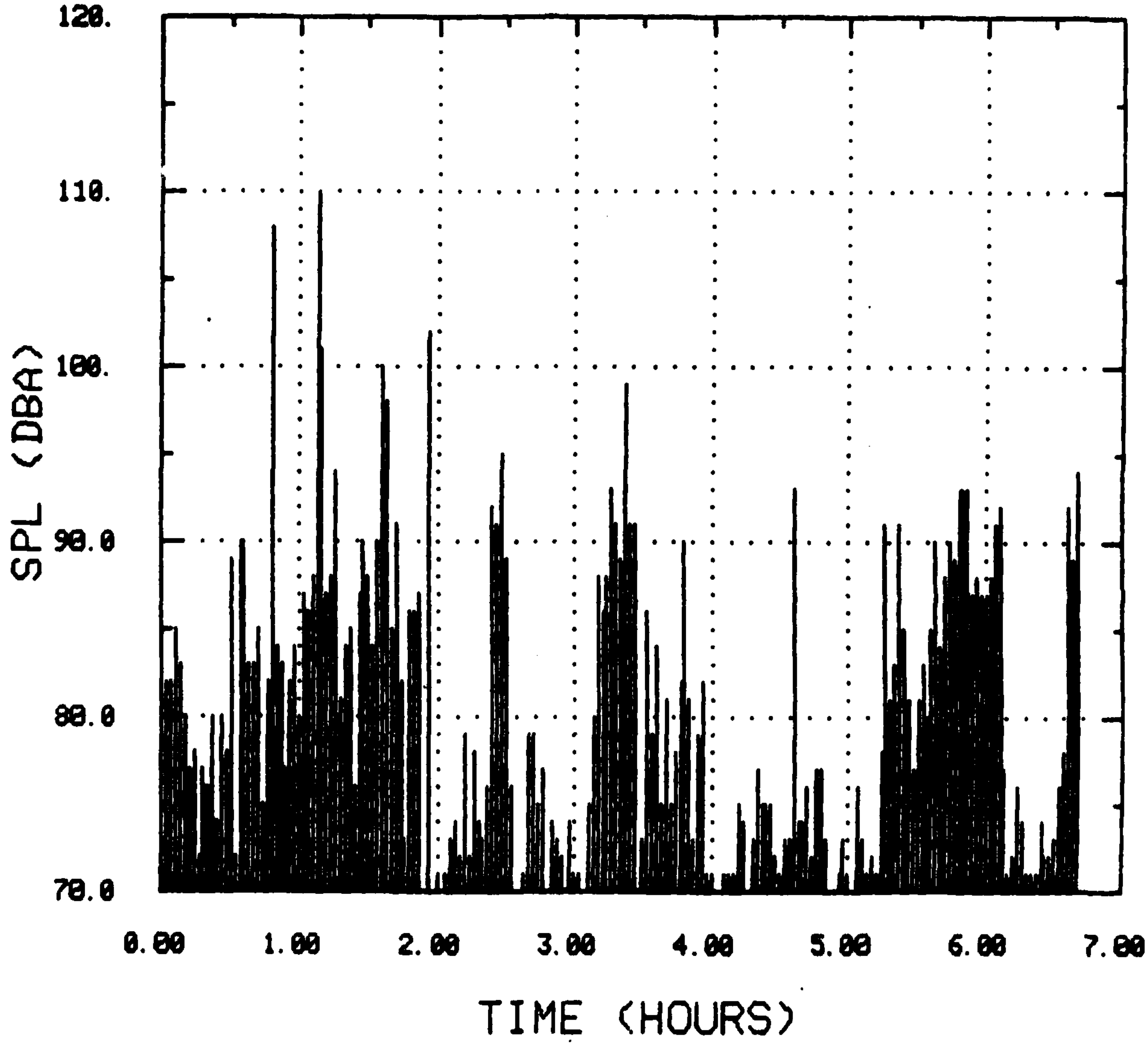
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 13



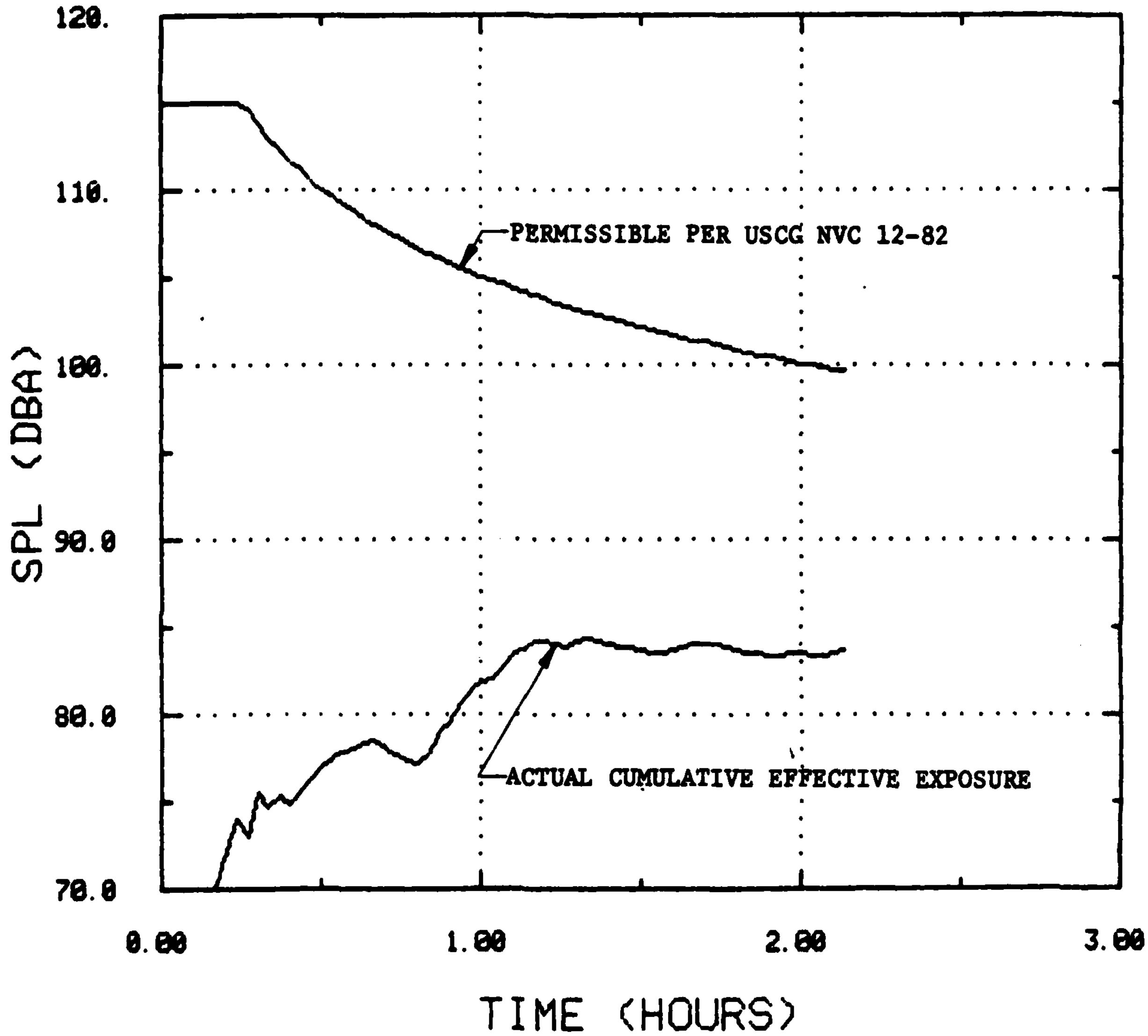
NOISE DOSIMETRY - SAMPLE 13



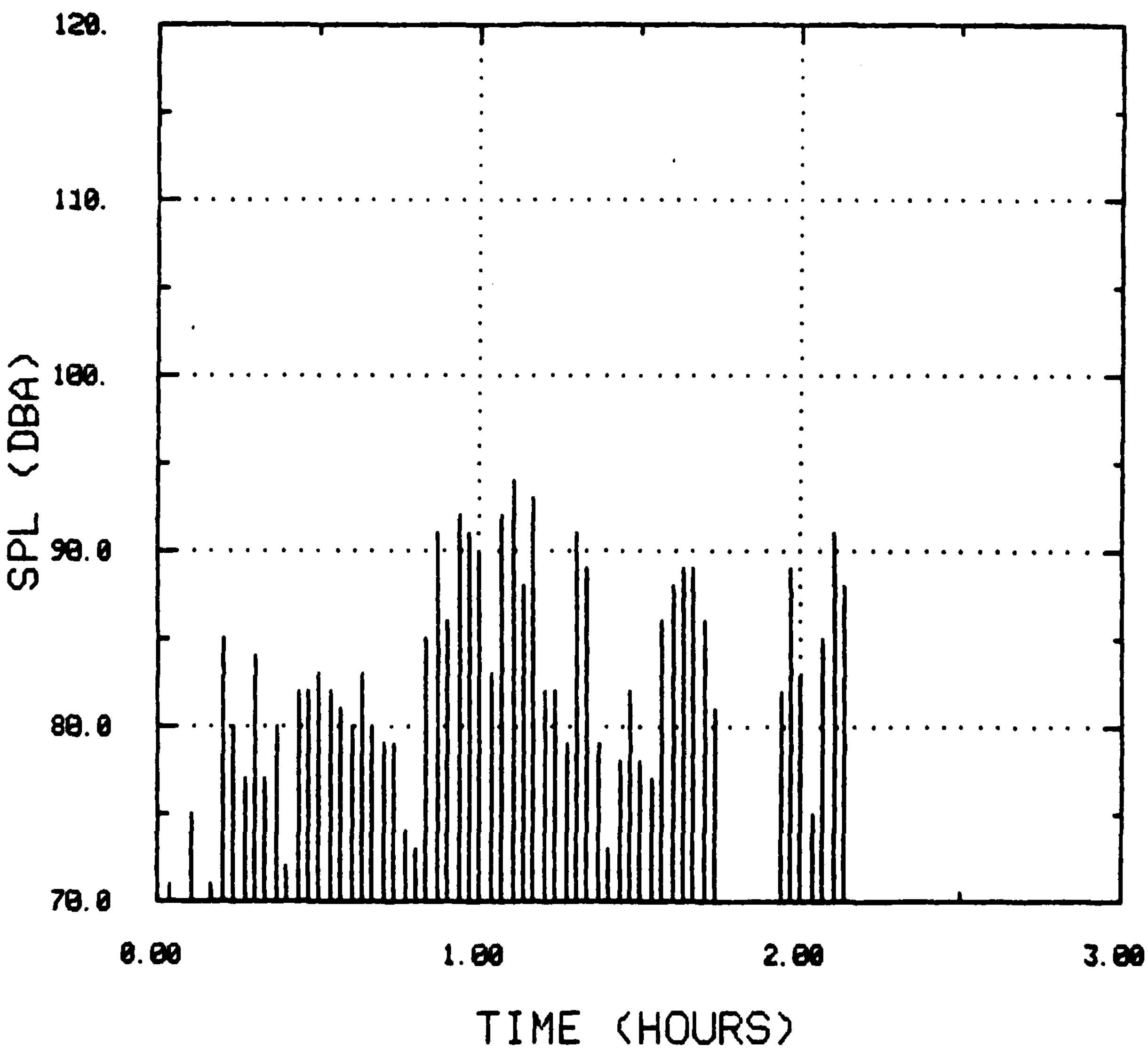
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 12



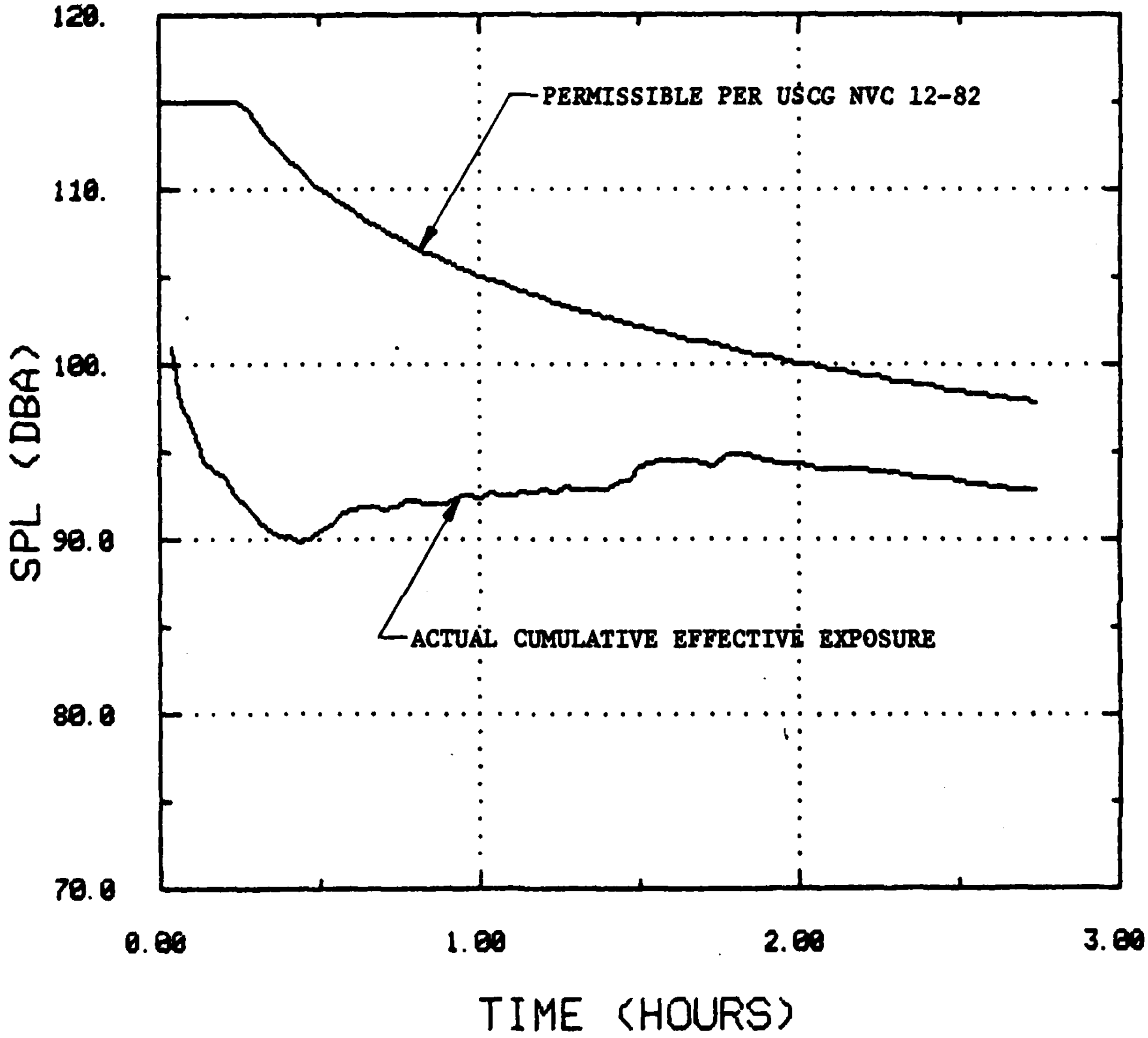
NOISE DOSIMETRY - SAMPLE 12



CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 11



NOISE DOSIMETRY - SAMPLE 11



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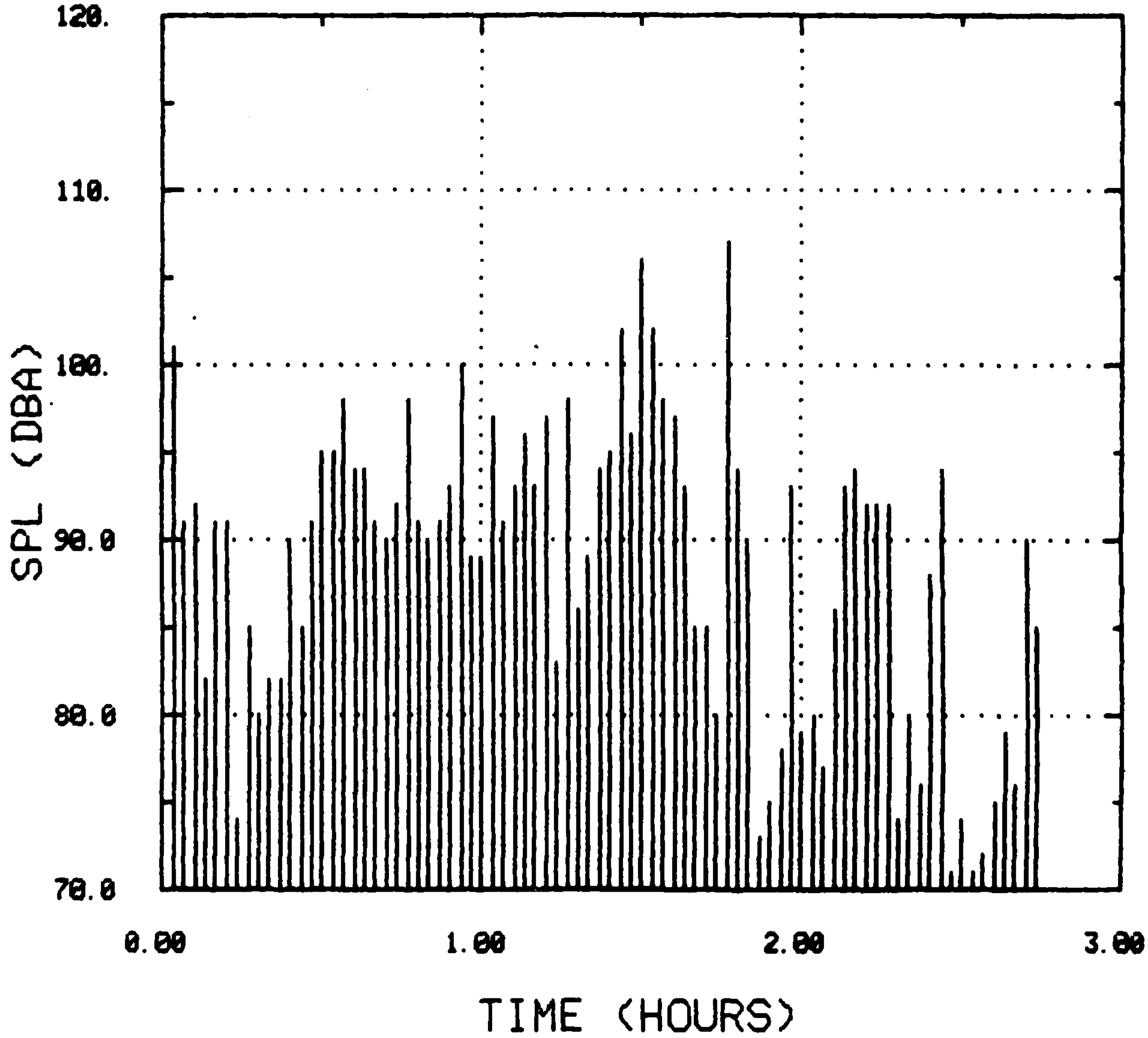
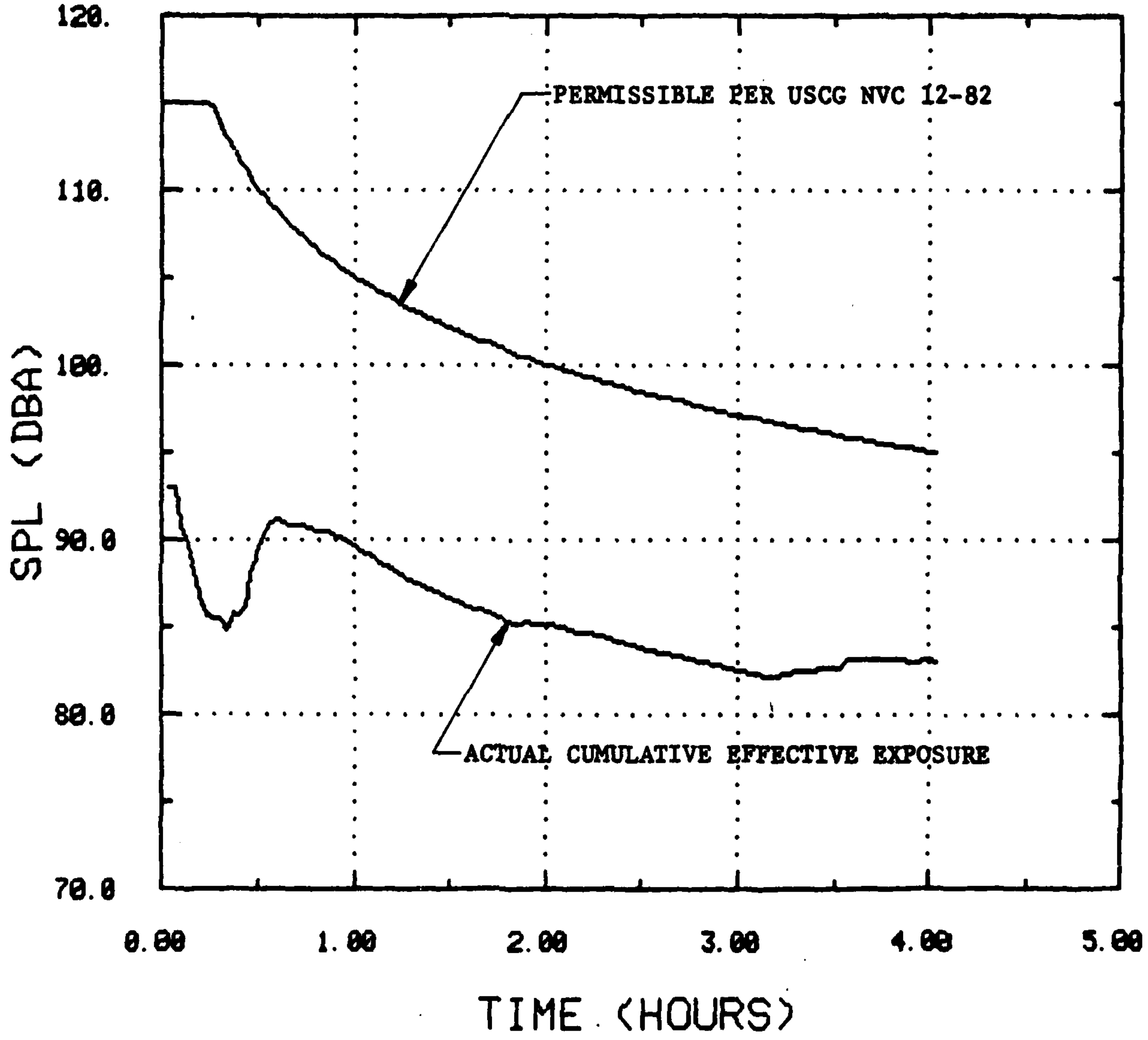


NOISE DOSIMETRY - SAMPLE 10



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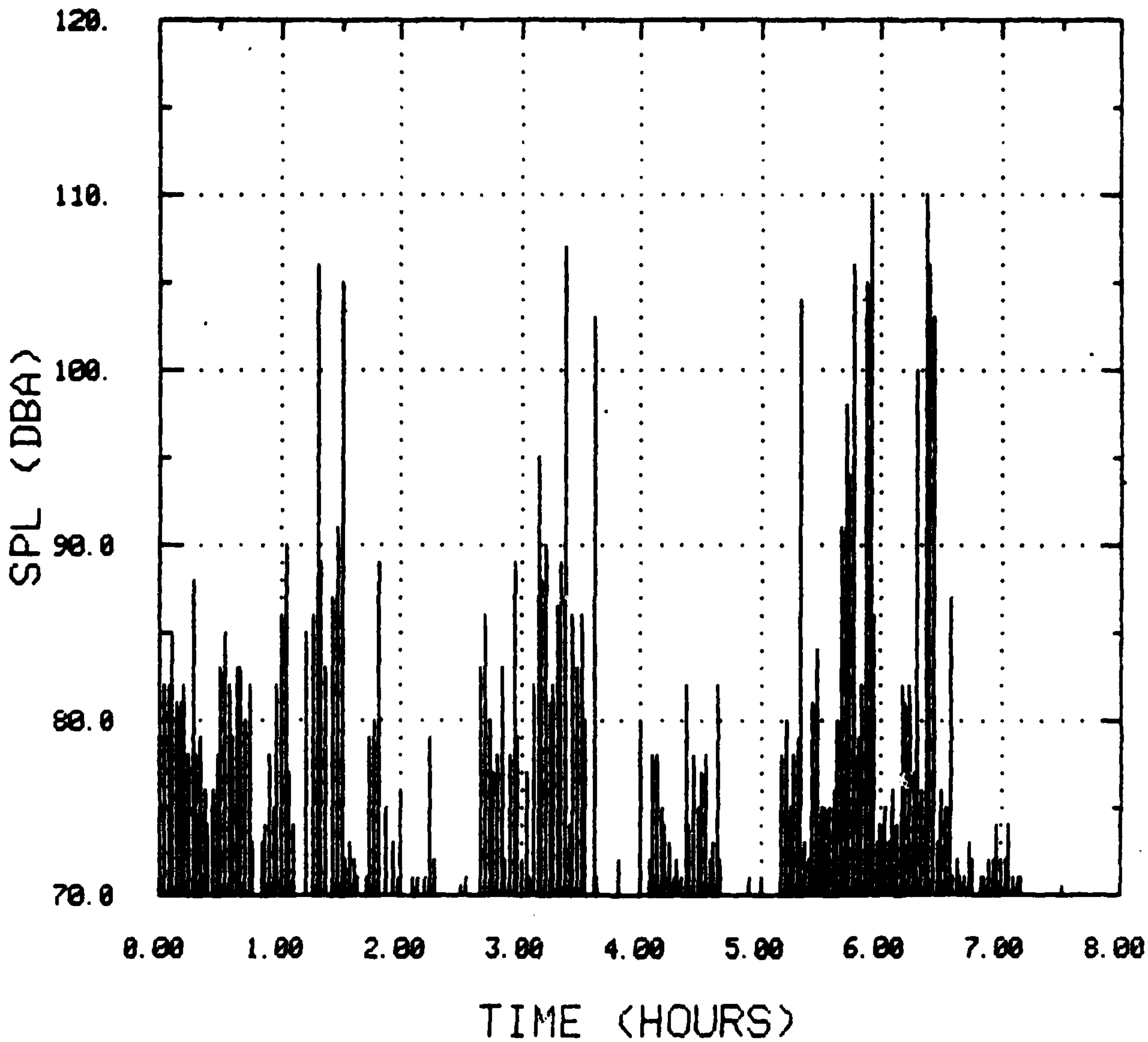
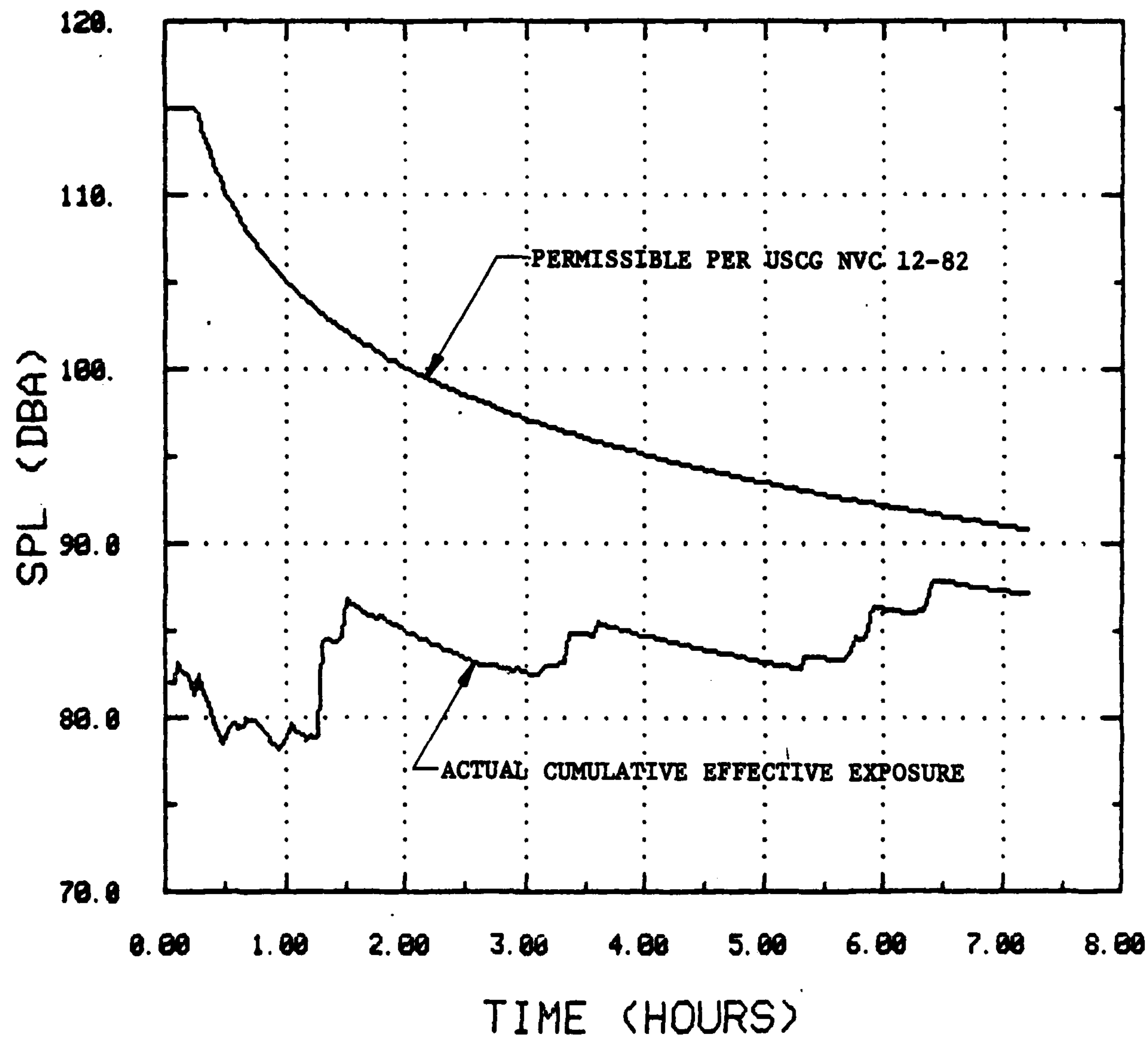
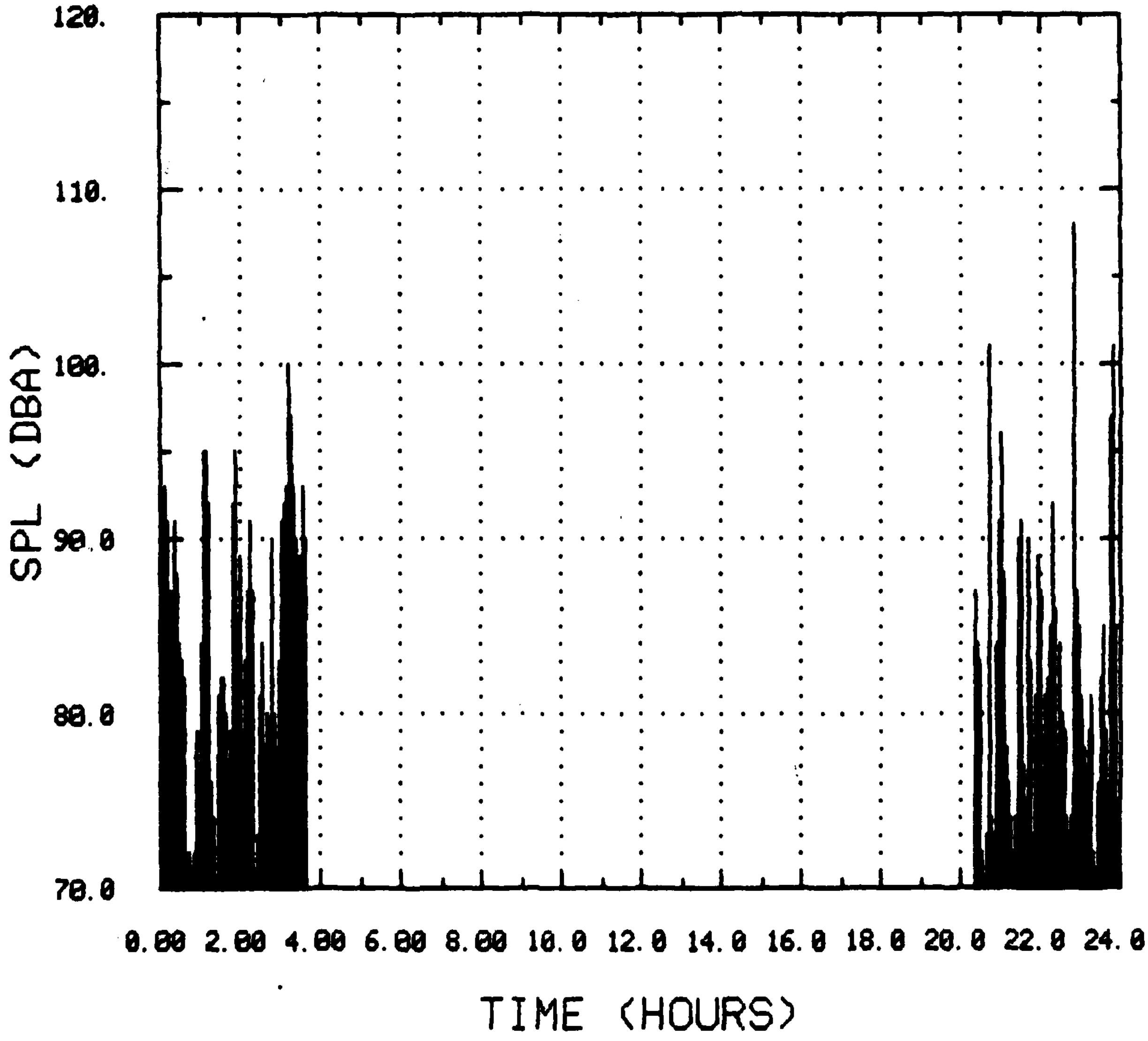


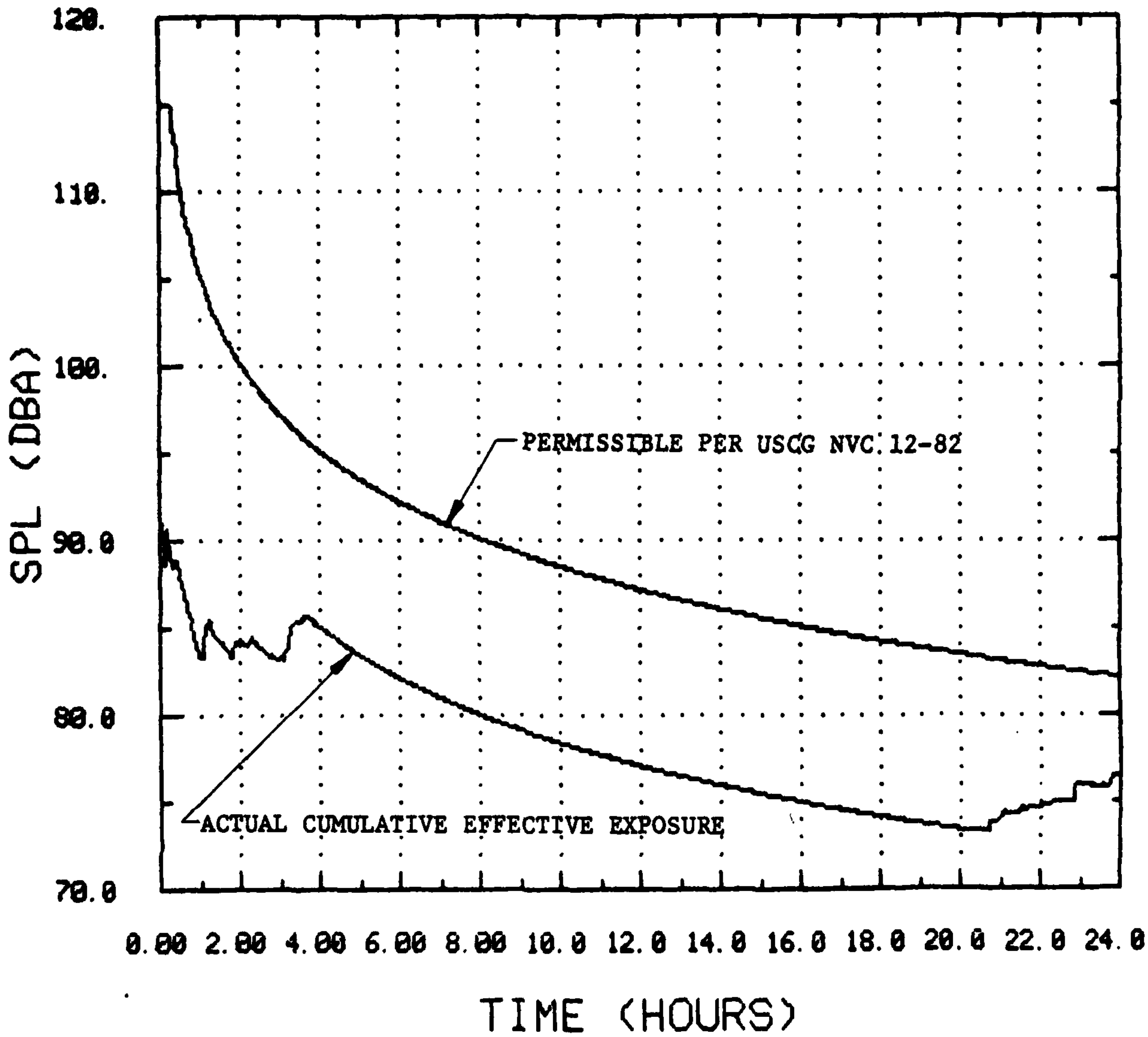
NOISE DOSIMETRY - SAMPLE 20



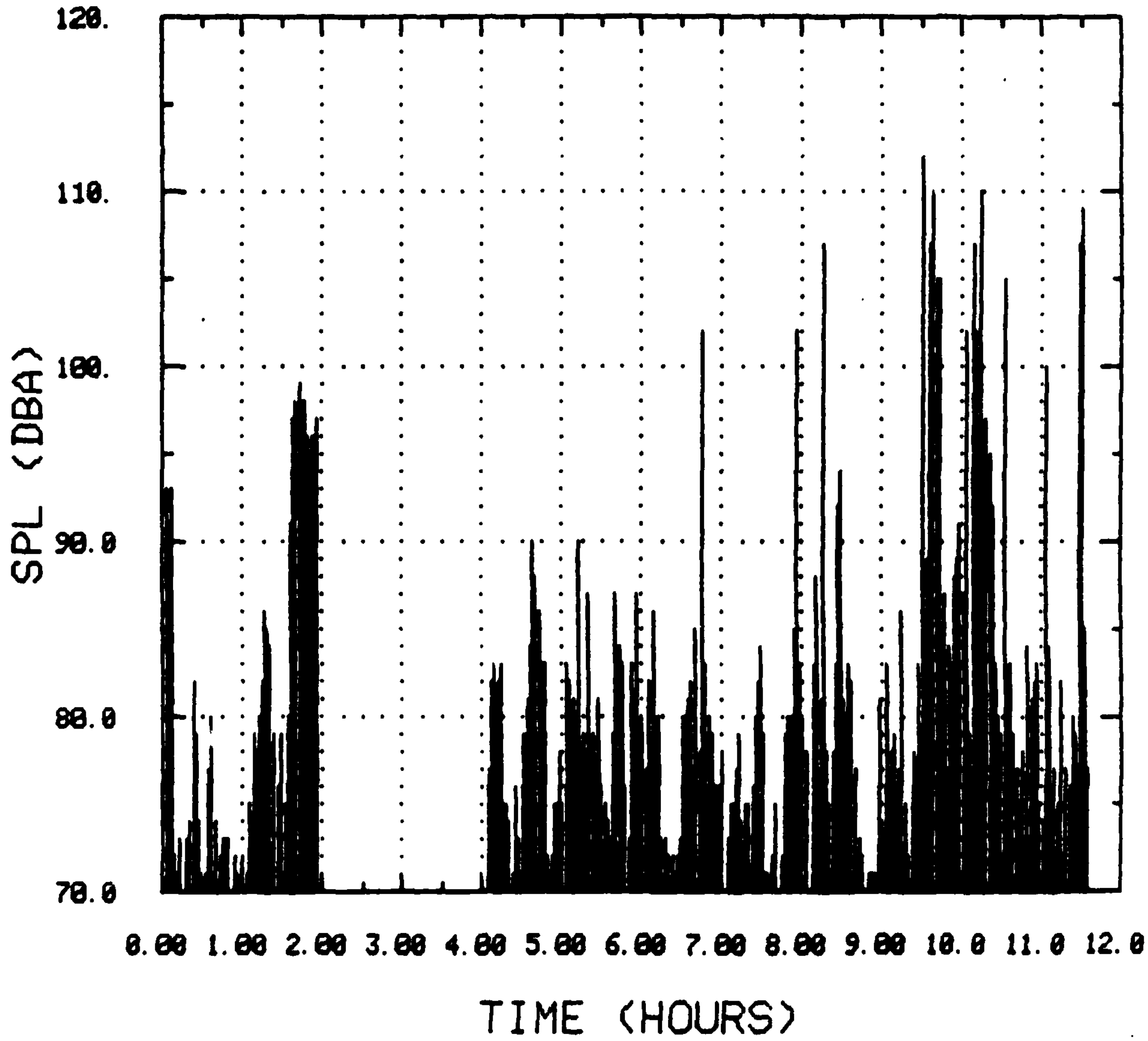
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 20



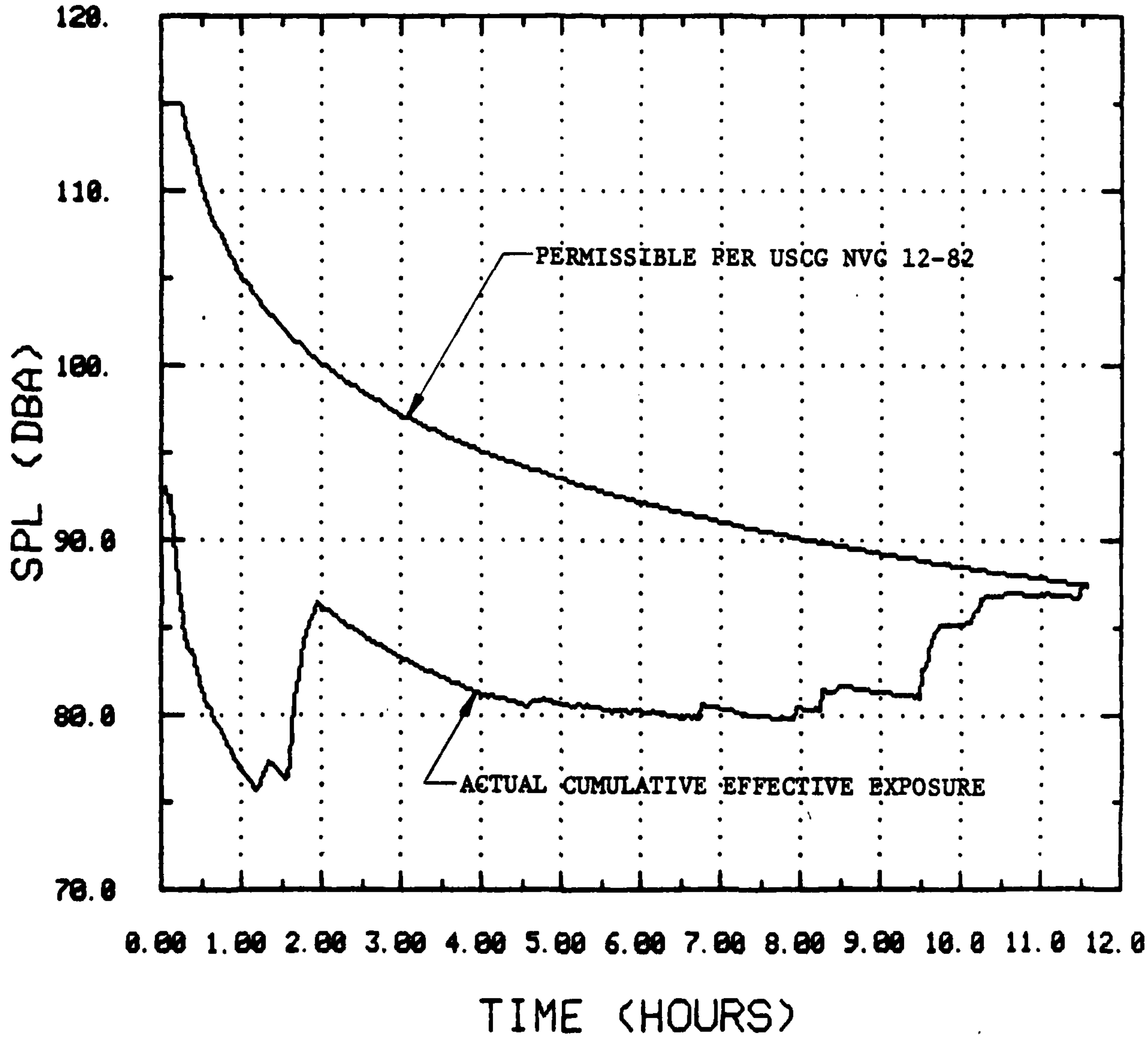
NOISE DOSIMETRY - 24 HOUR SAMPLE (SAMPLES 2 AND 7)



CUMULATIVE EFFECTIVE EXPOSURE - 24 HOUR SAMPLE (SAMPLES 2 AND 7)



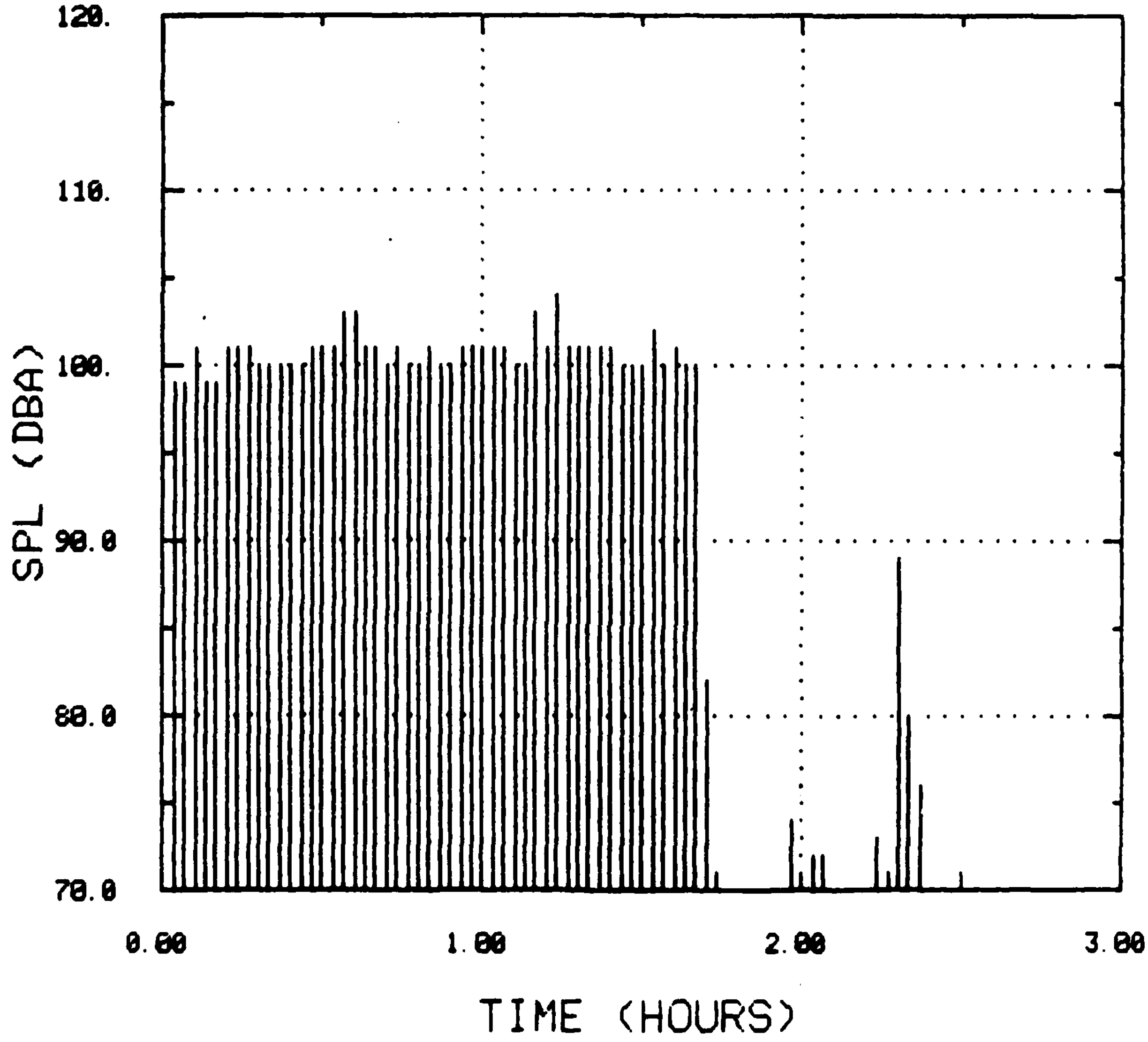
NOISE DOSIMETRY - 12 HOUR SAMPLE (SAMPLES 5 AND 8)



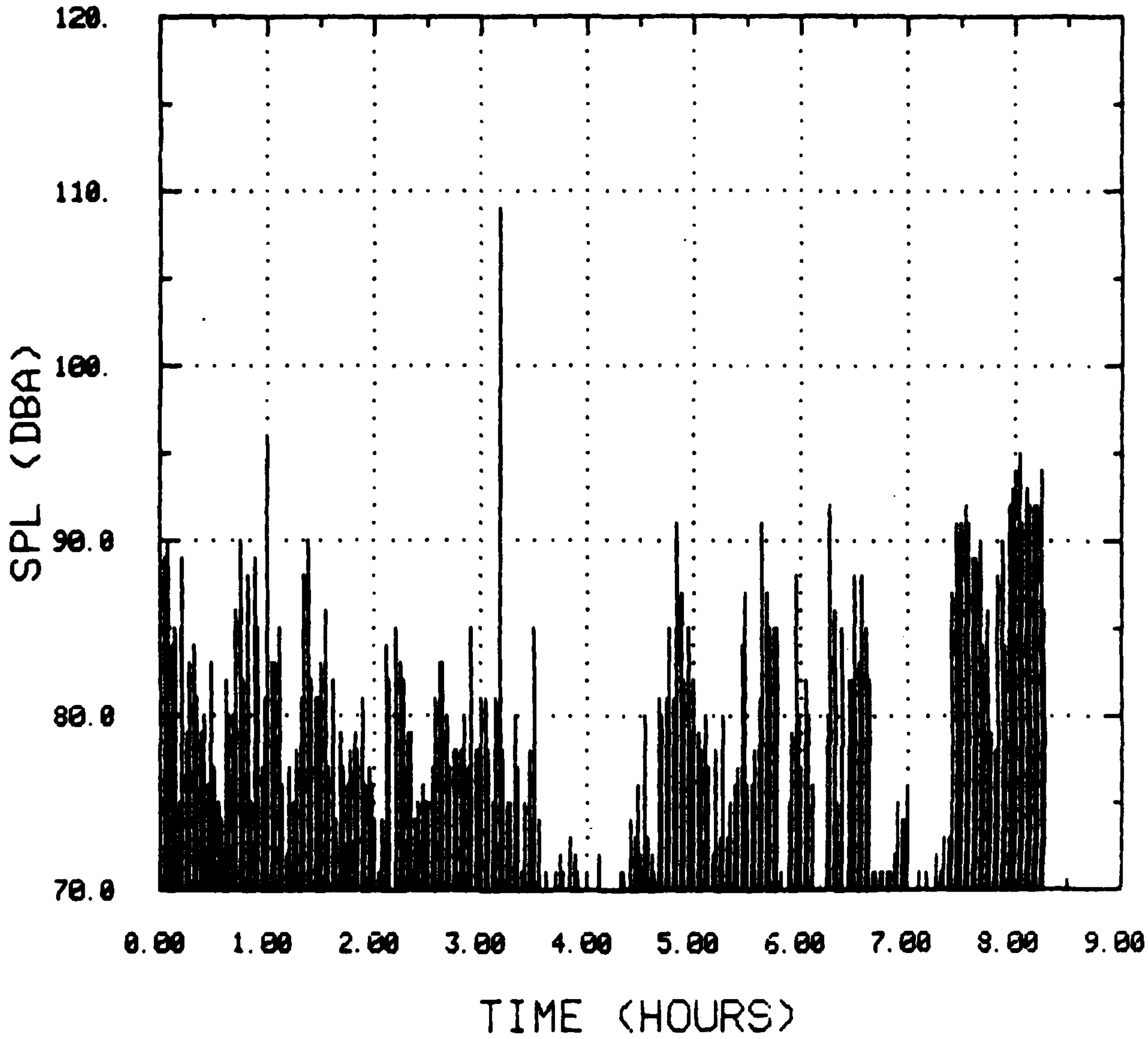
CUMULATIVE EFFECTIVE EXPOSURE - 12 HOUR SAMPLE (SAMPLES 5 AND 8)

APPENDIX F-2

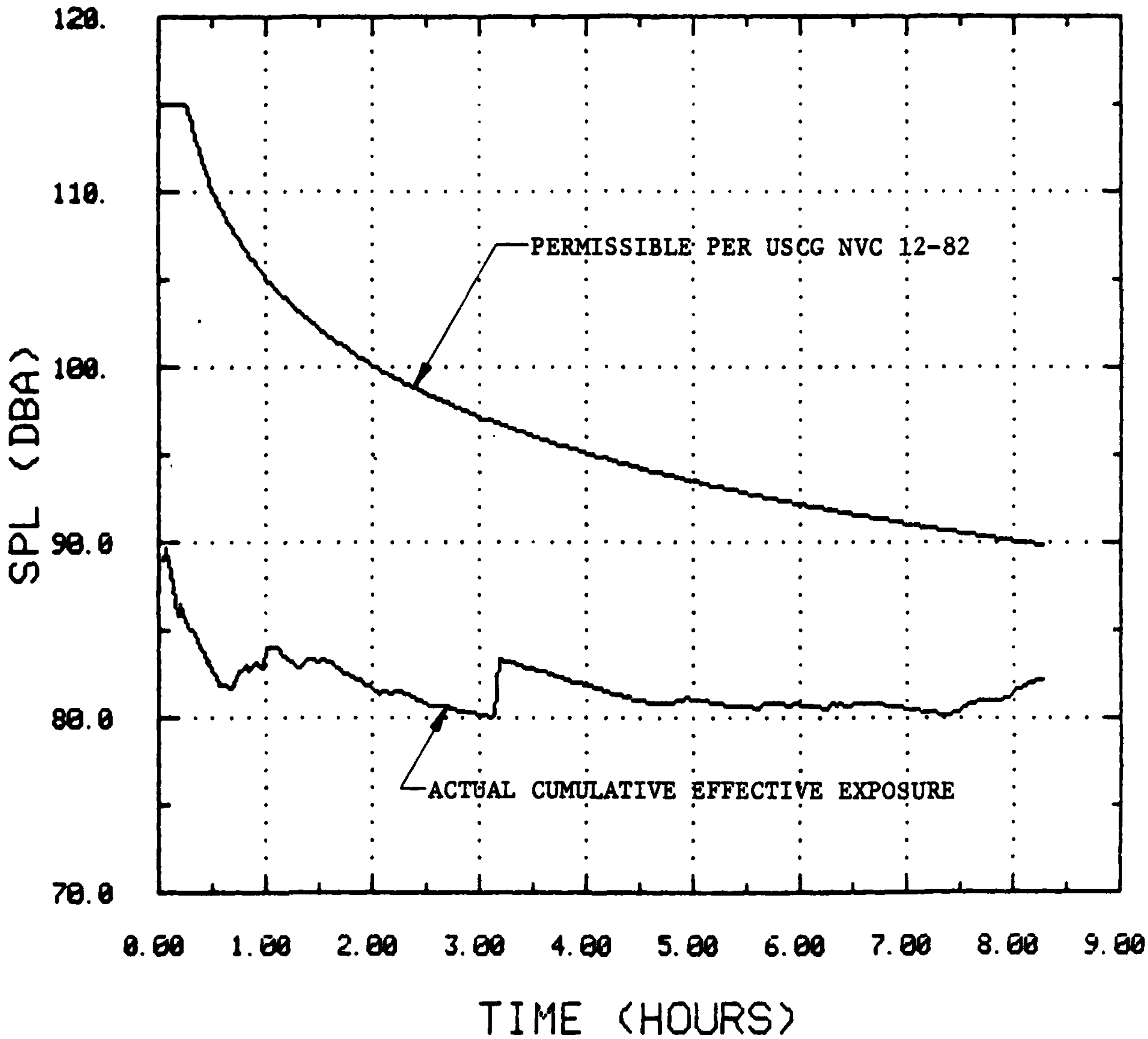
NOISE DOSIMETRY DURING TANK PROCESSING



NOISE DOSIMETRY - SAMPLE 15



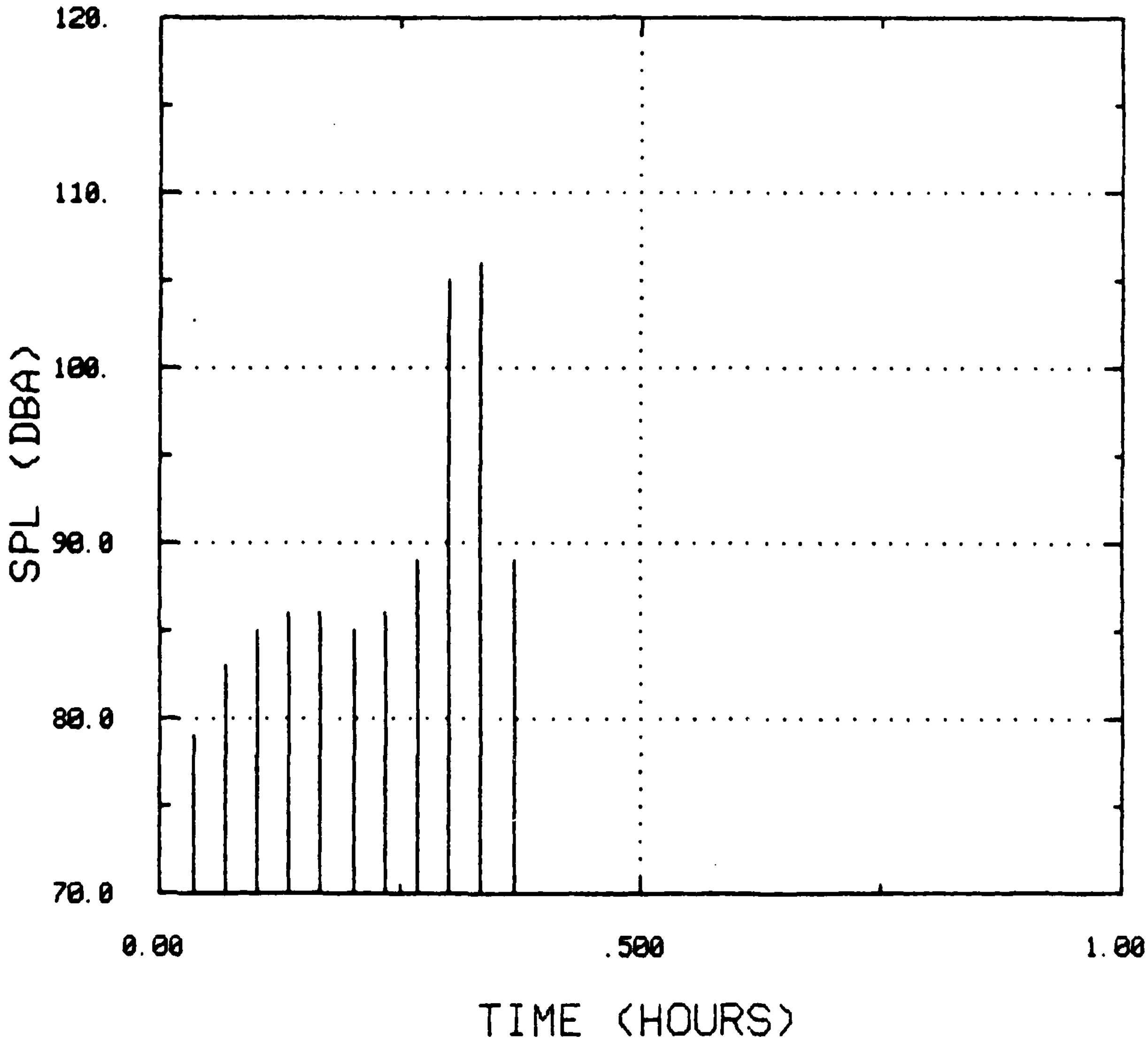
NOISE DOSIMETRY - SAMPLE 24



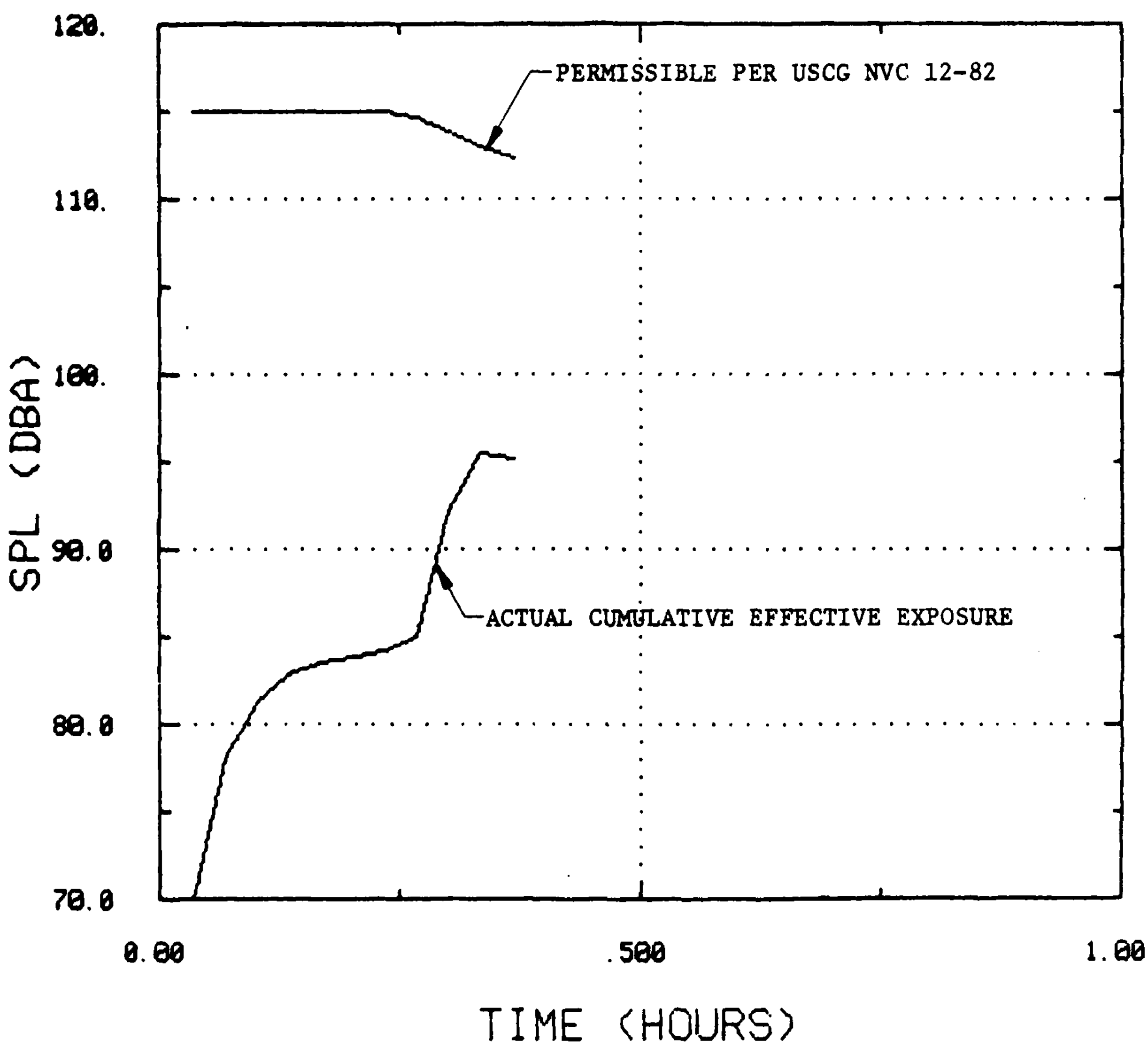
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 24

APPENDIX F-3

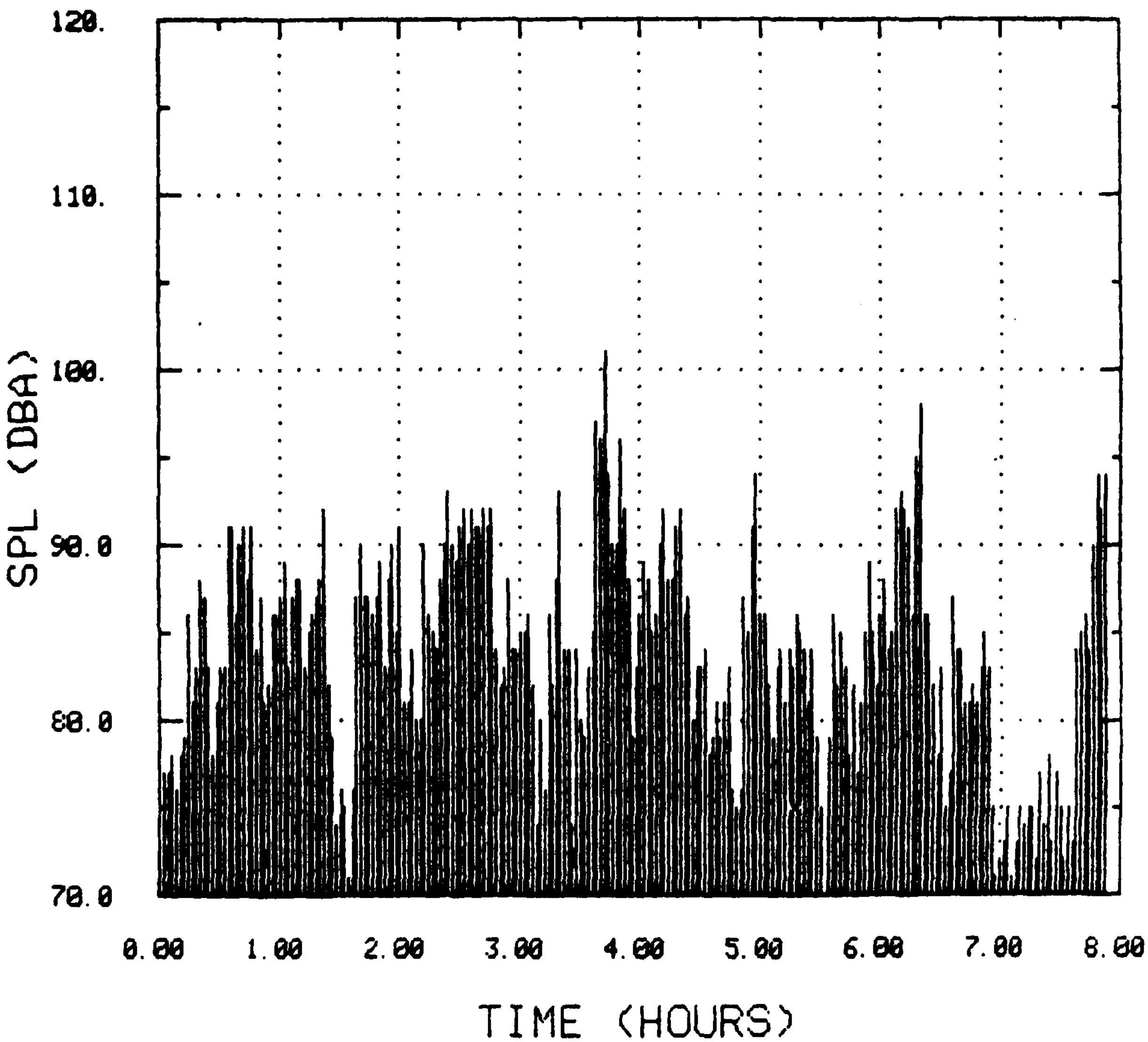
NOISE DOSIMETRY DURING TANK ENTRIES



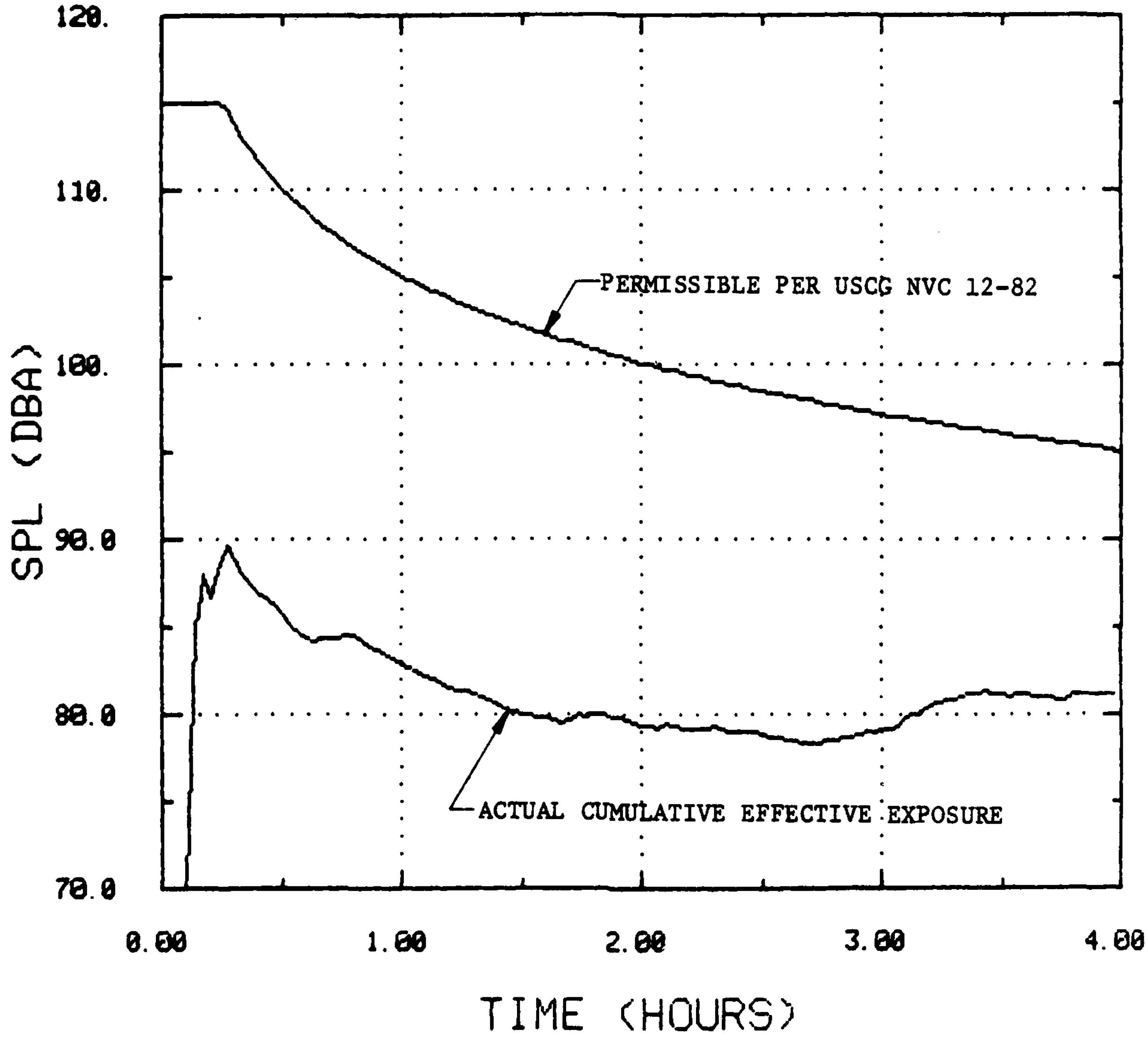
NOISE DOSIMETRY - SAMPLE 21



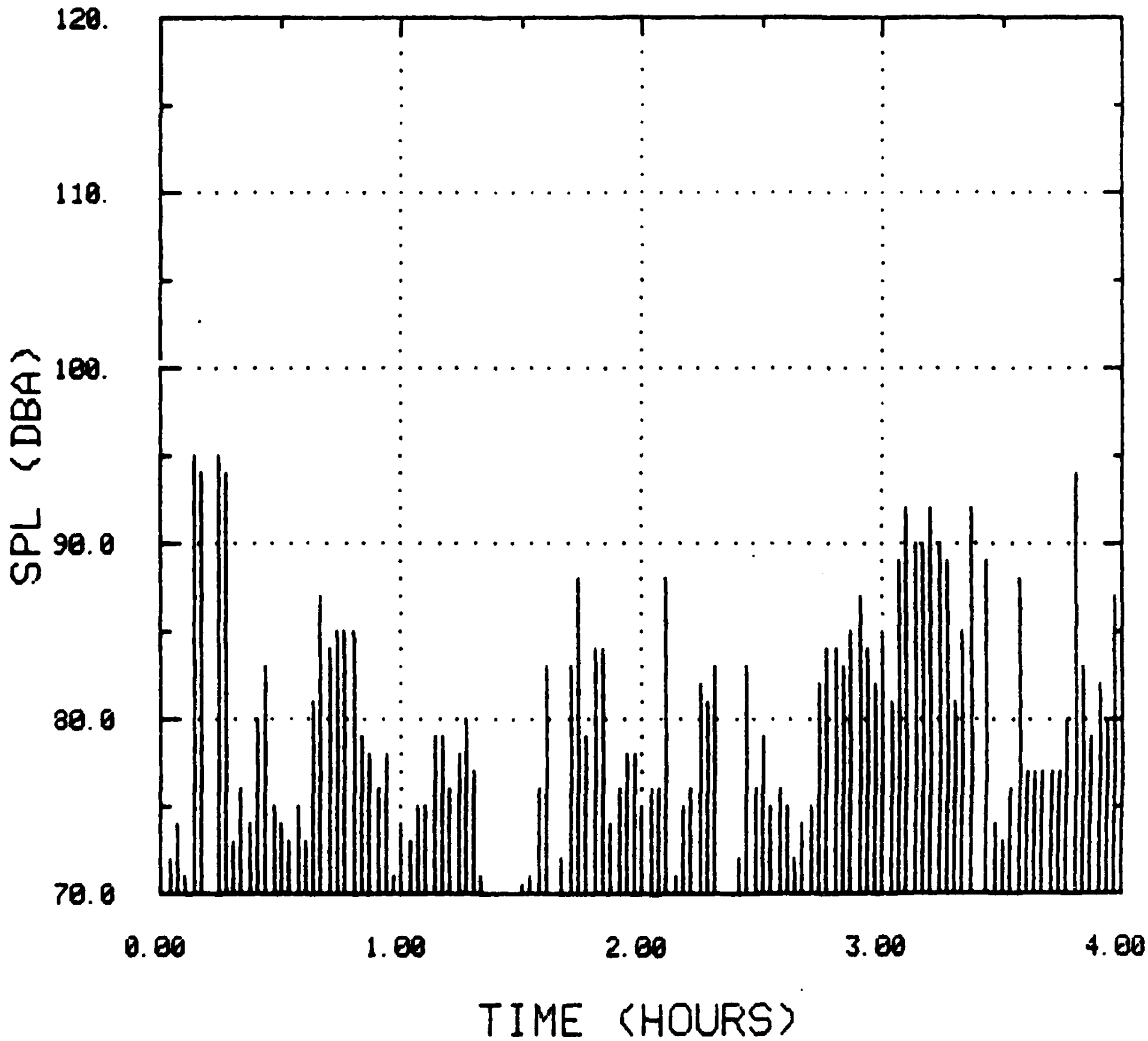
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 21



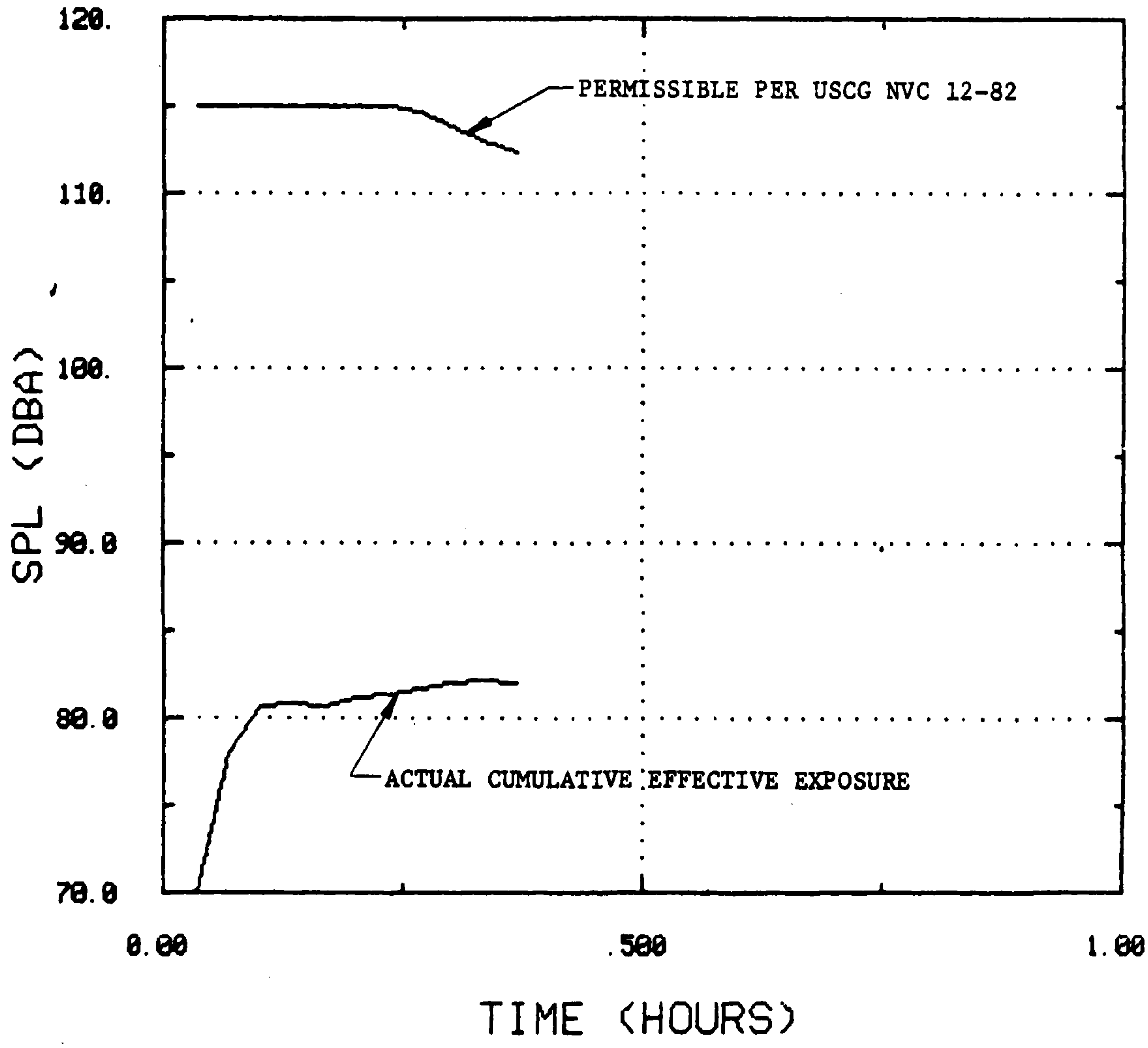
NOISE DOSIMETRY - SAMPLE 28



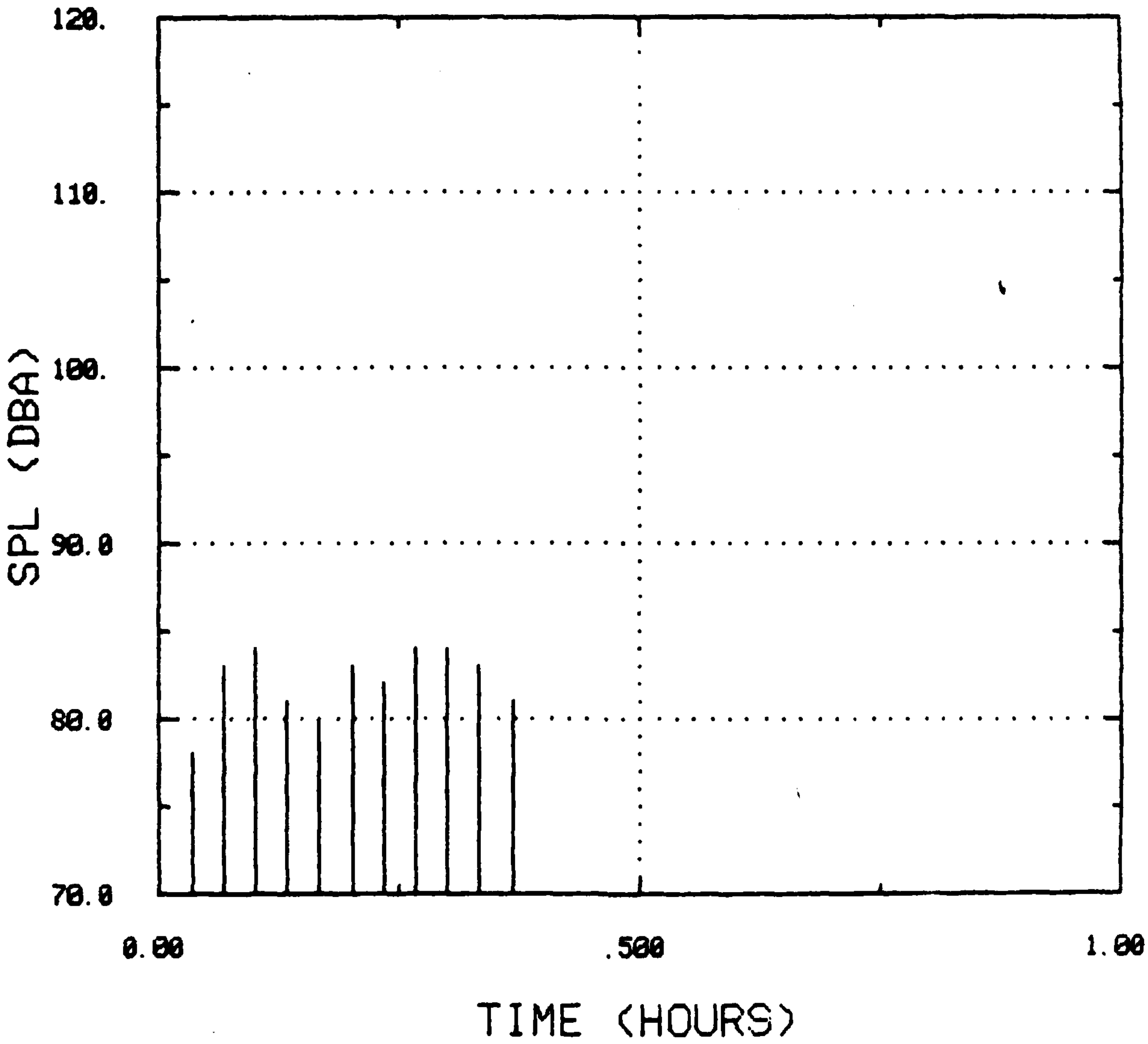
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 27



NOISE DOSIMETRY - SAMPLE 27



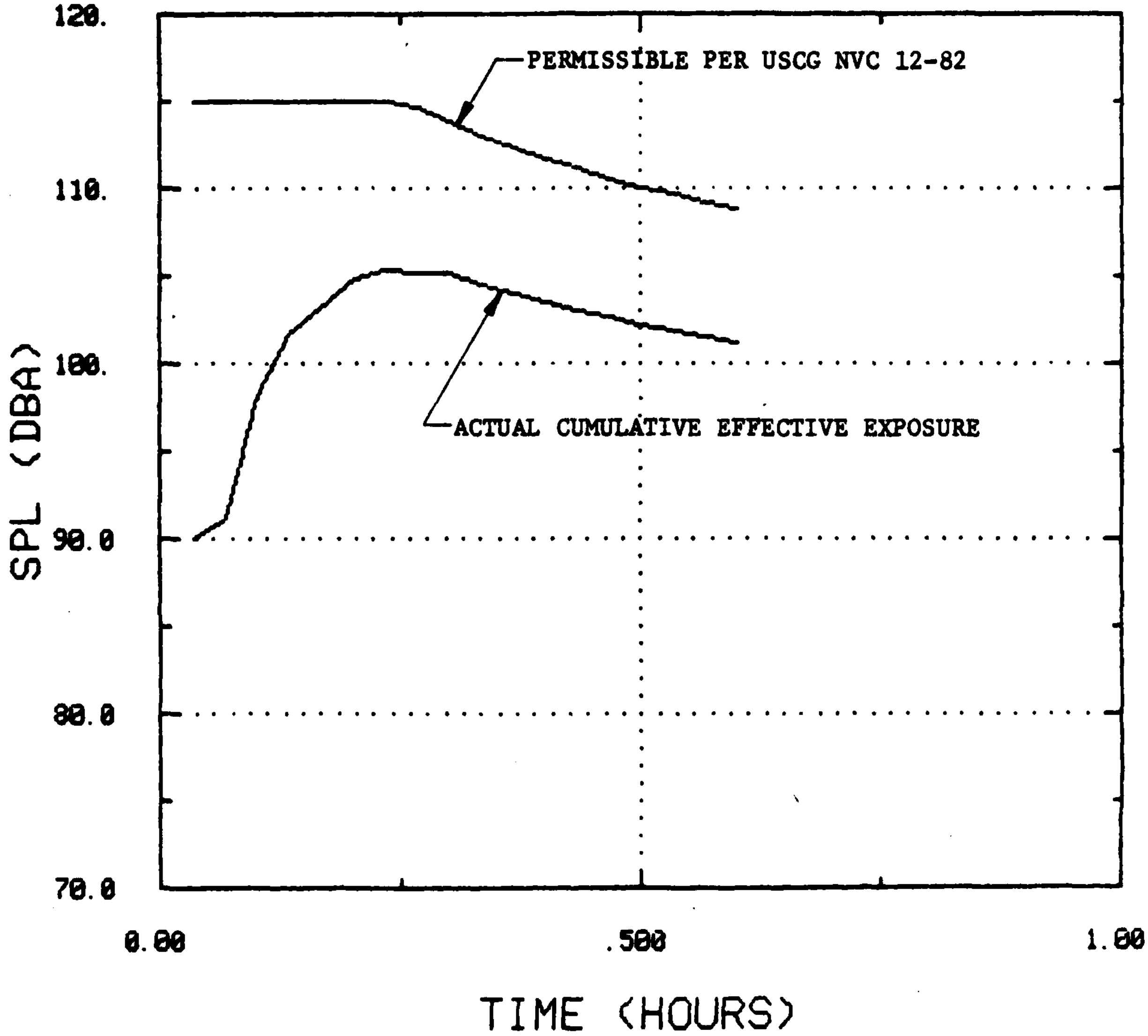
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 18



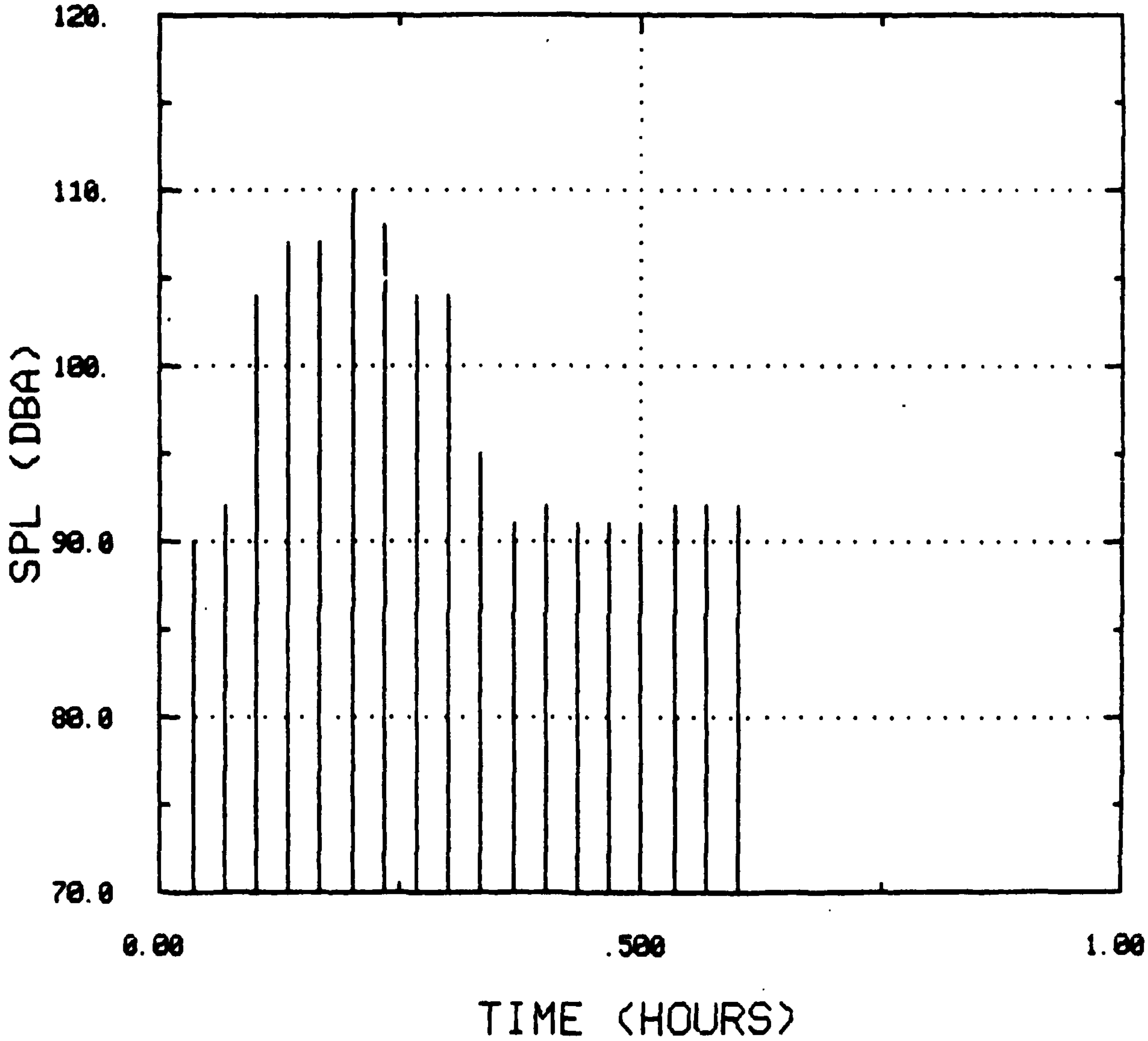
NOISE DOSIMETRY - SAMPLE 18

APPENDIX F-4

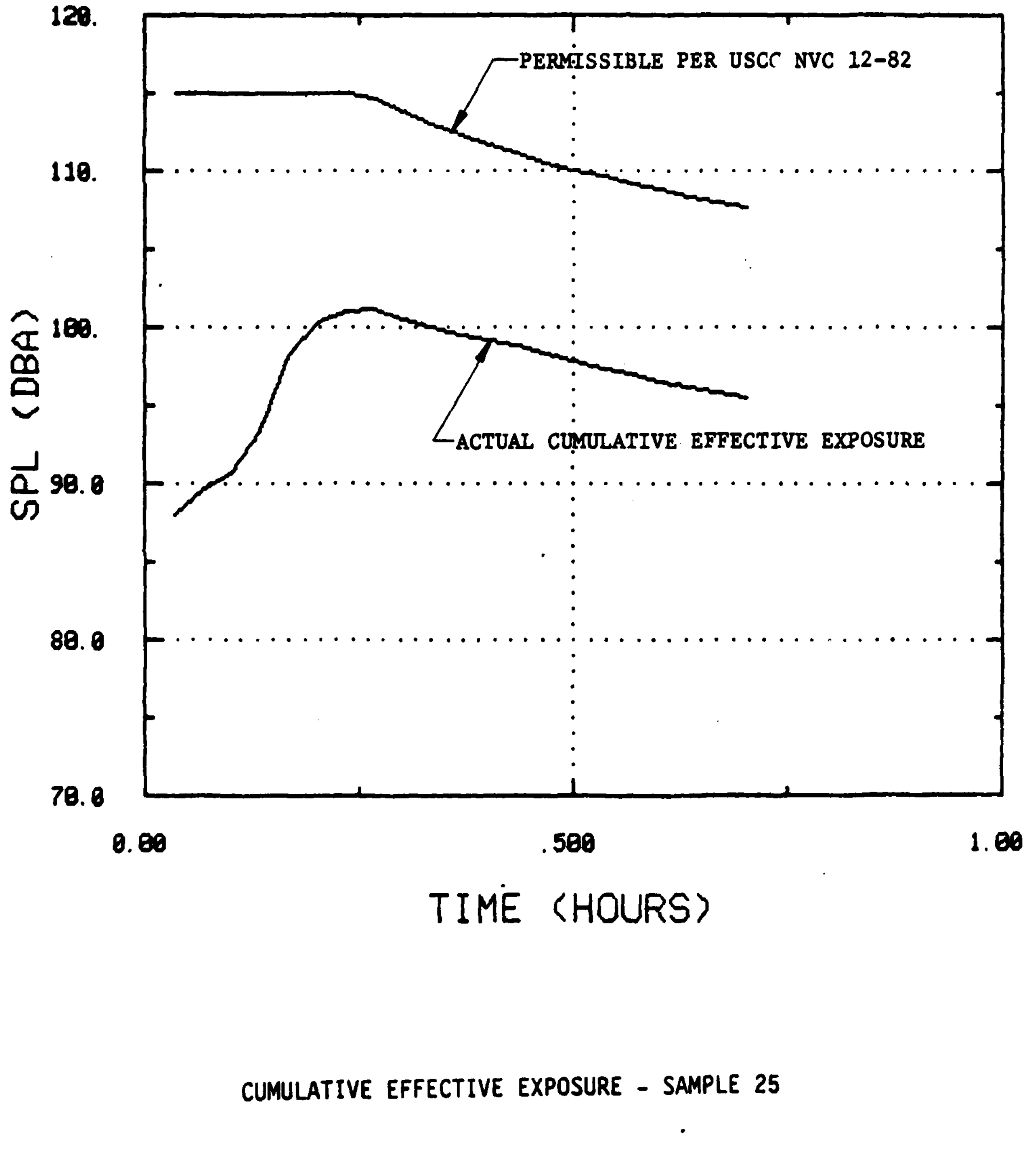
NOISE DOSIMETRY DURING PRODUCT LOADING



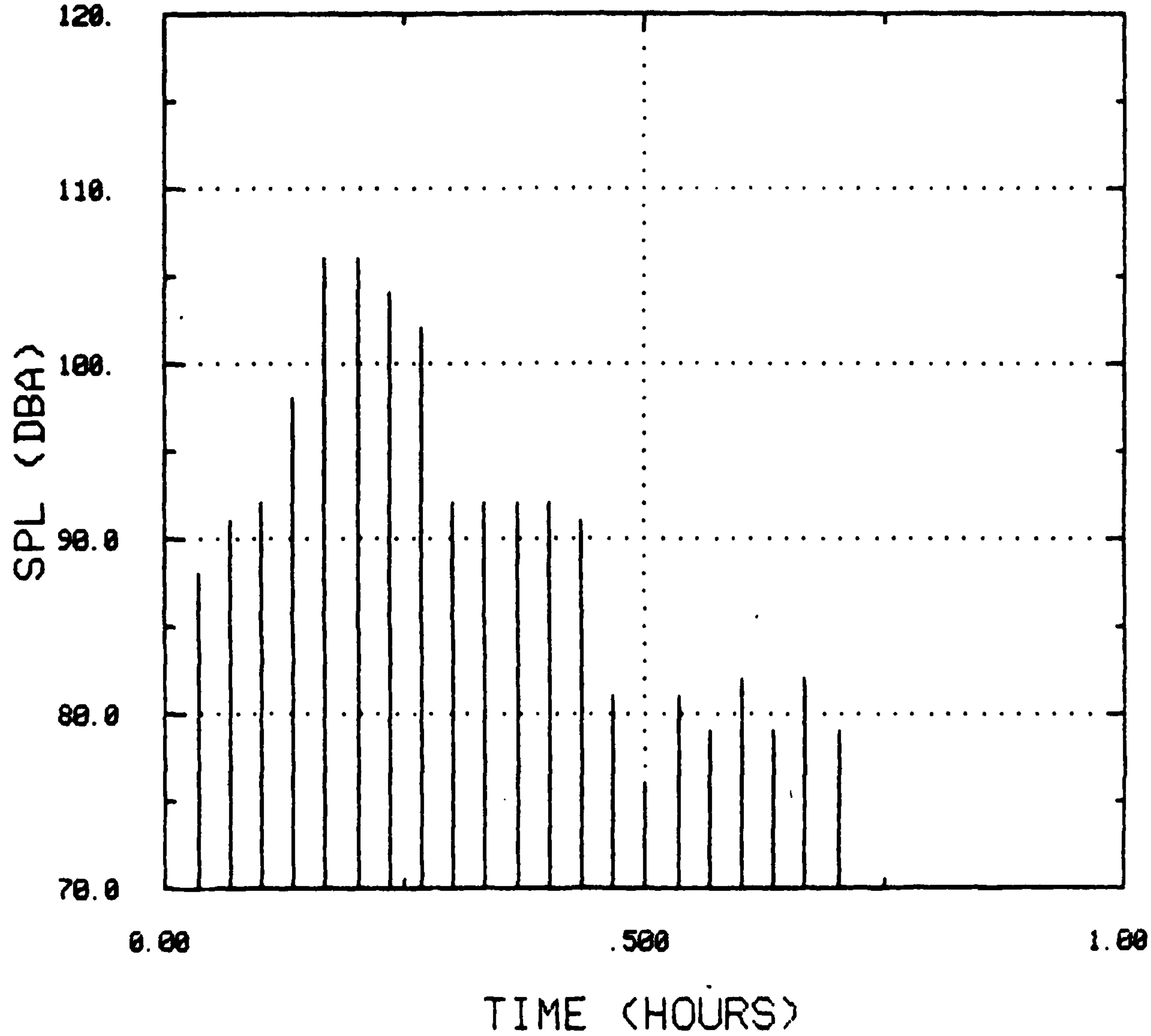
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 26



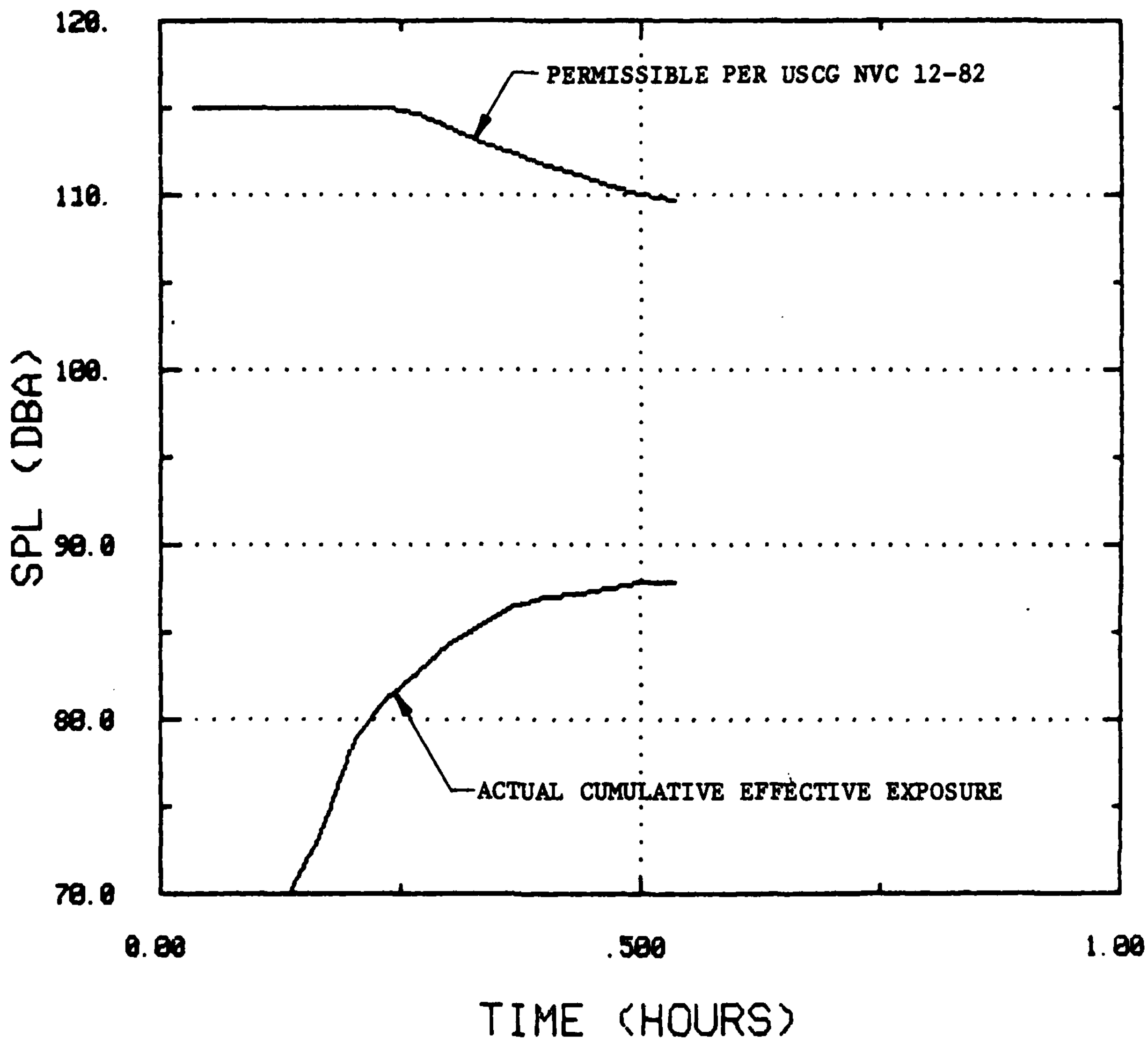
NOISE DOSIMETRY - SAMPLE 26



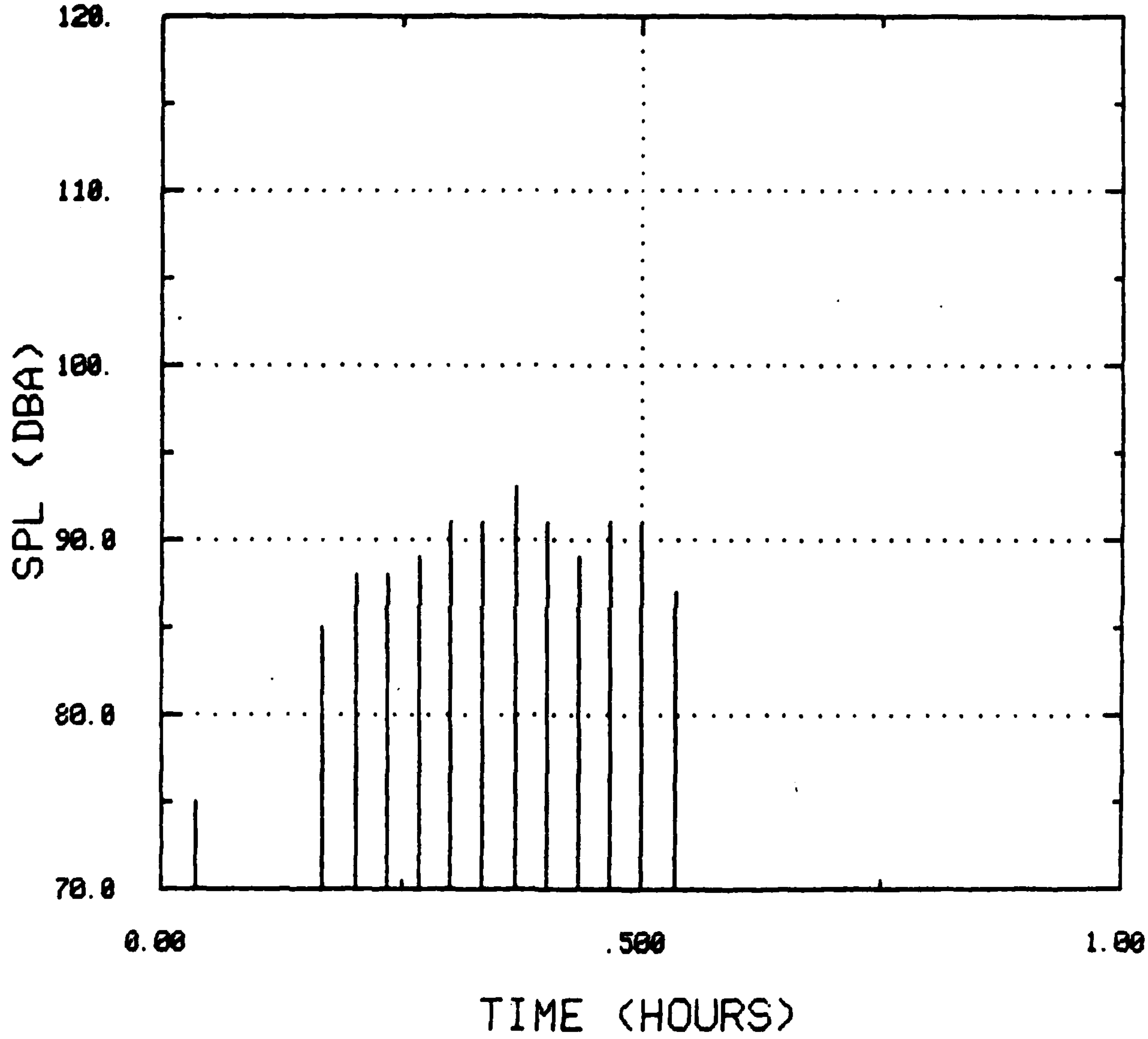
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 25



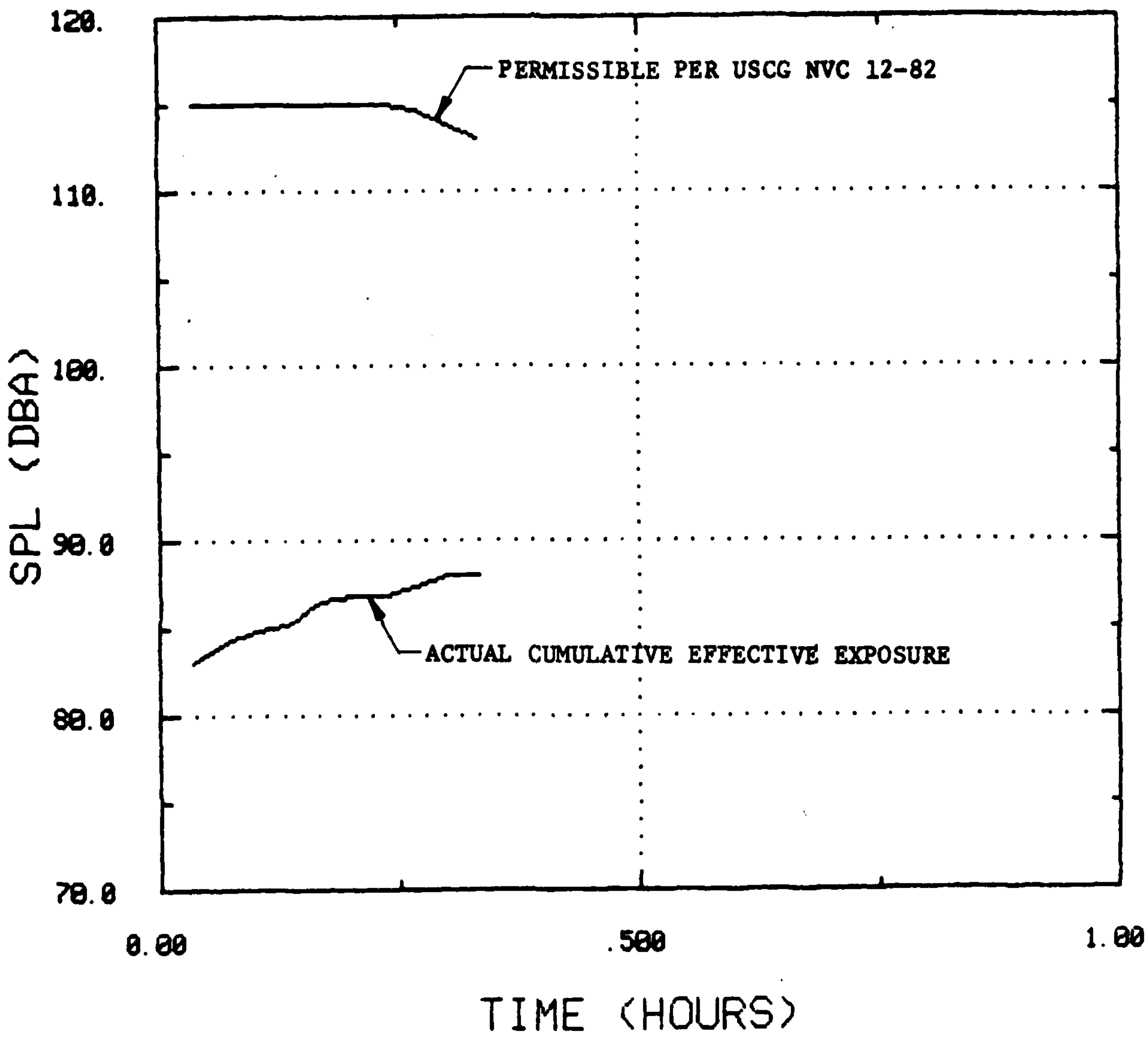
NOISE DOSIMETRY - SAMPLE 25



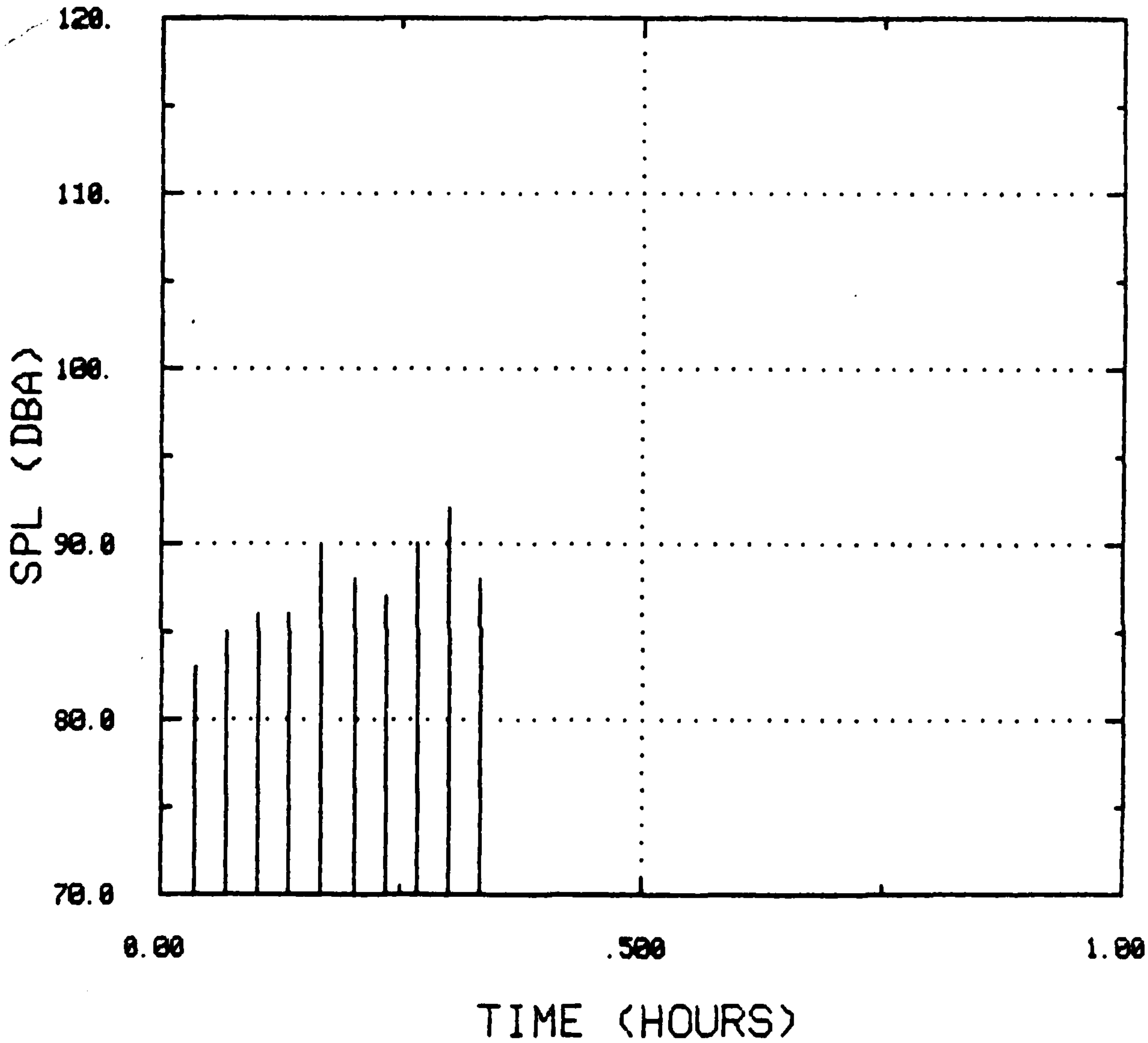
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 23



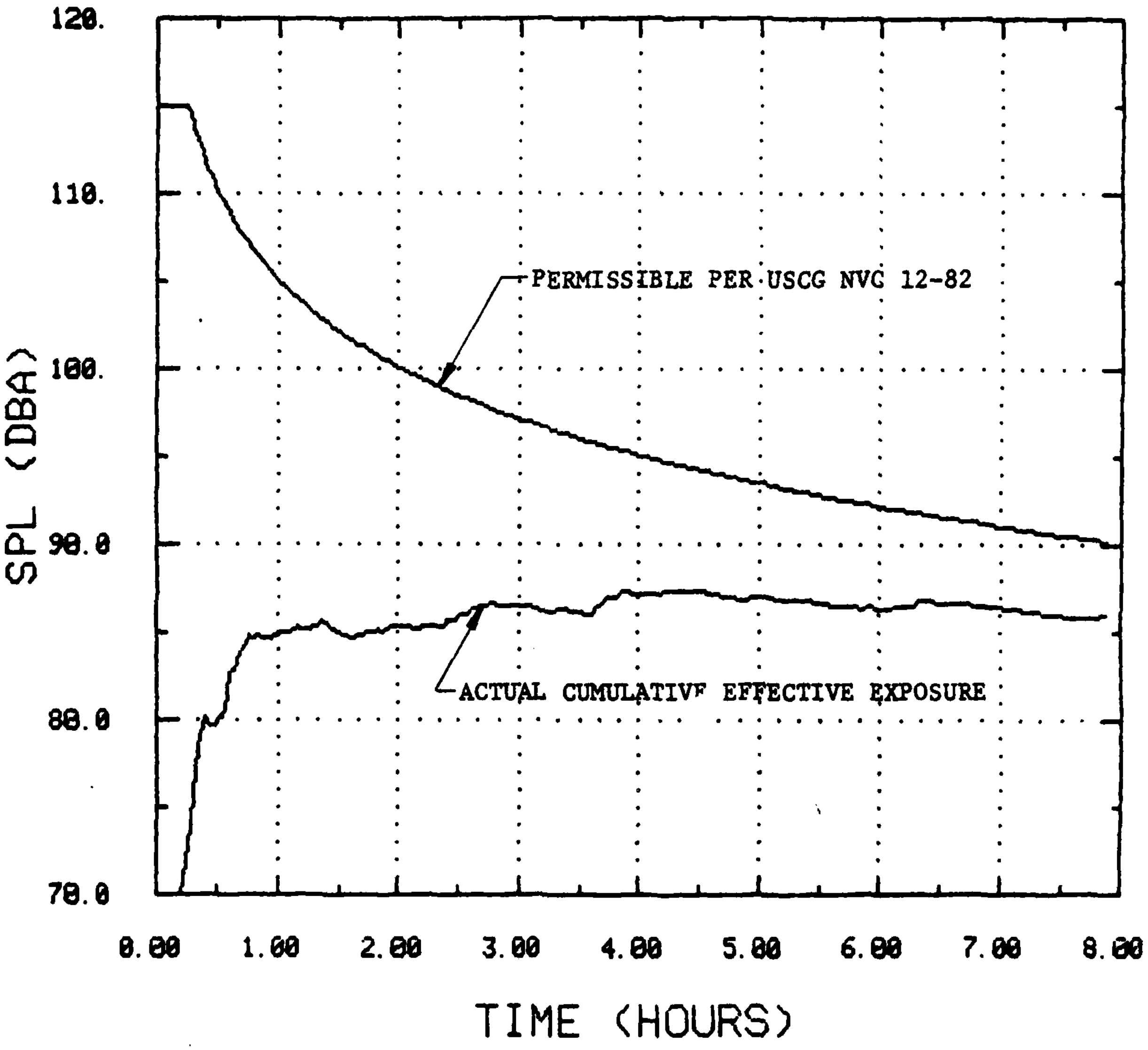
NOISE DOSIMETRY - SAMPLE 23



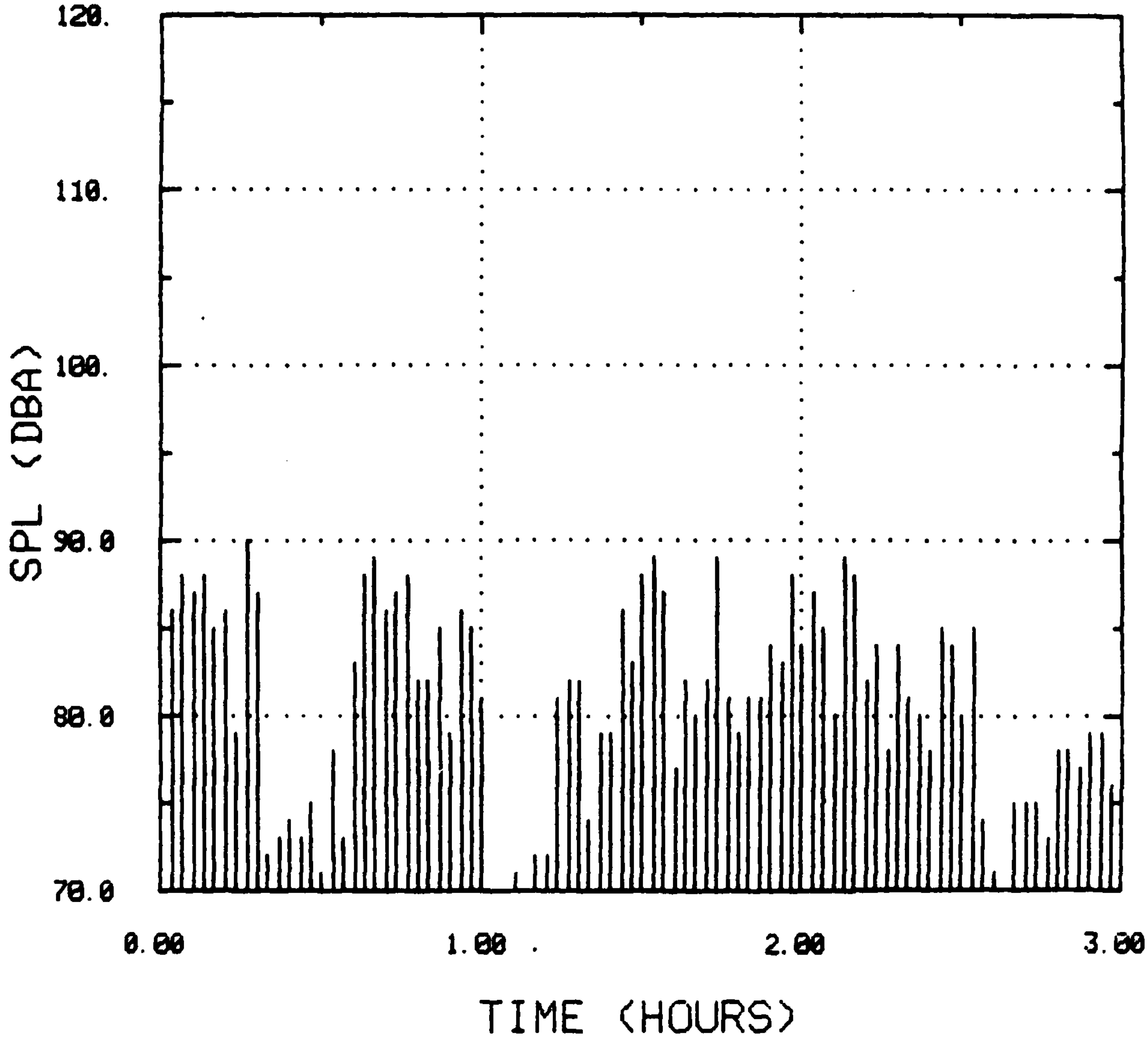
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 22



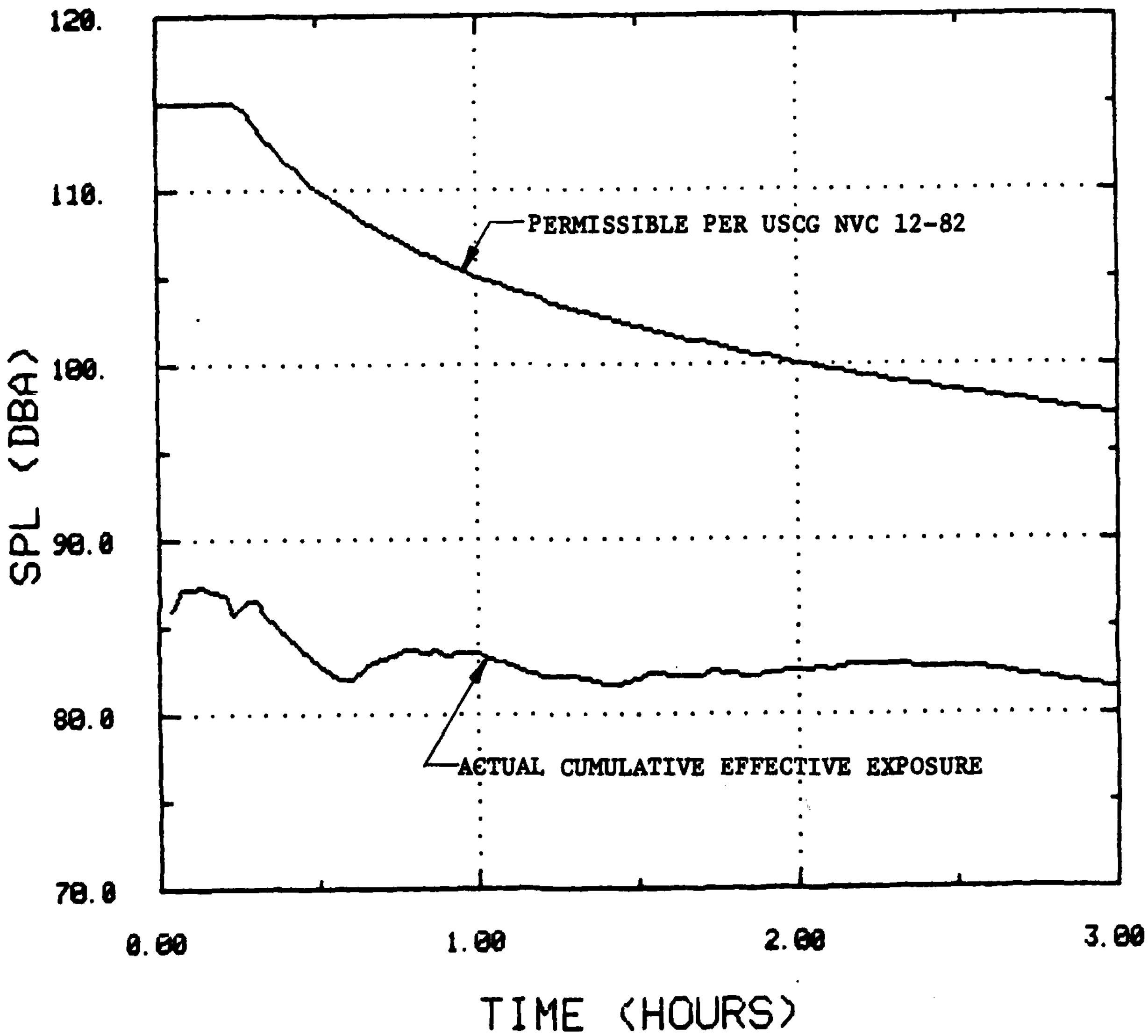
NOISE DOSIMETRY - SAMPLE 22



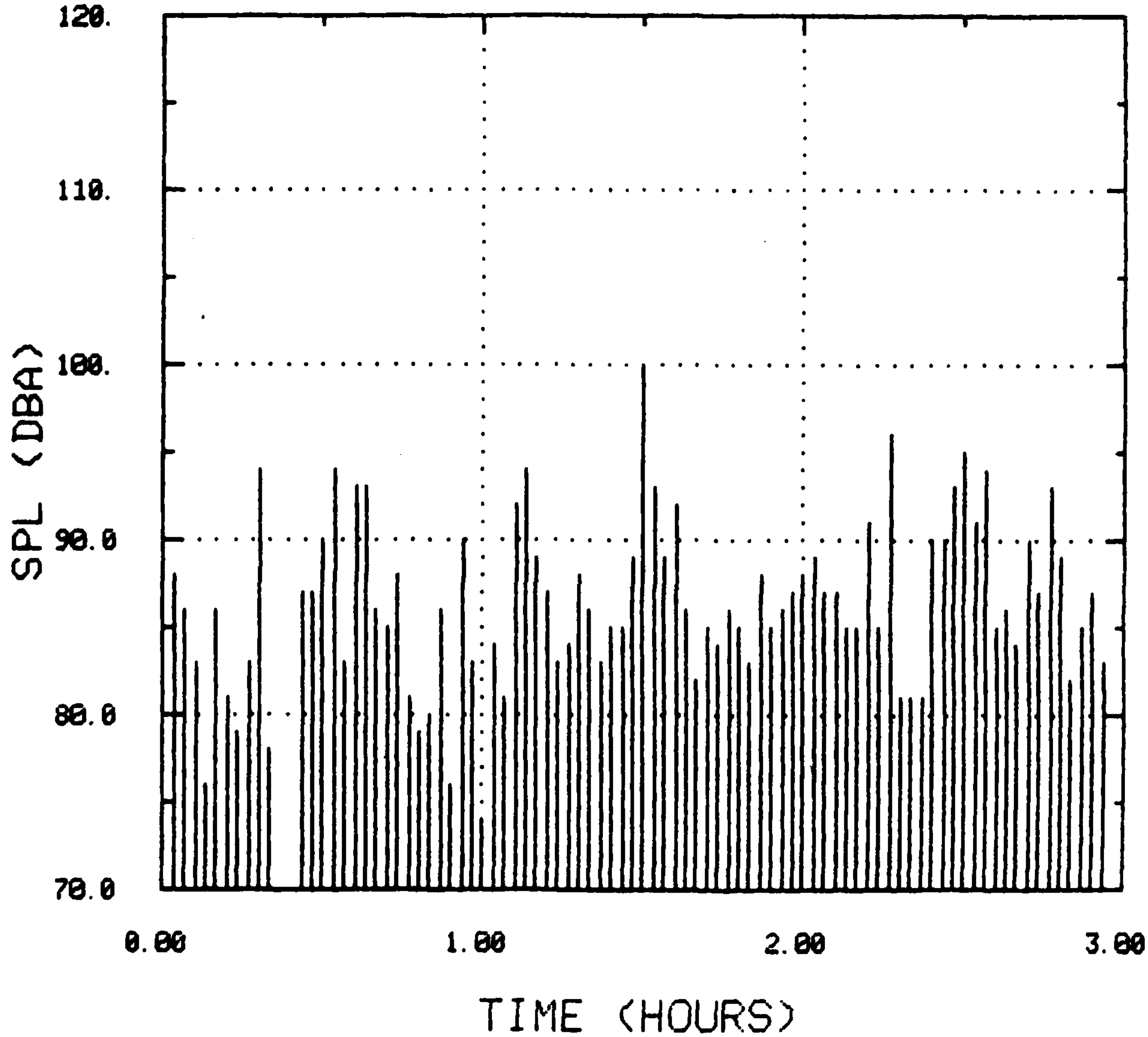
CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 28



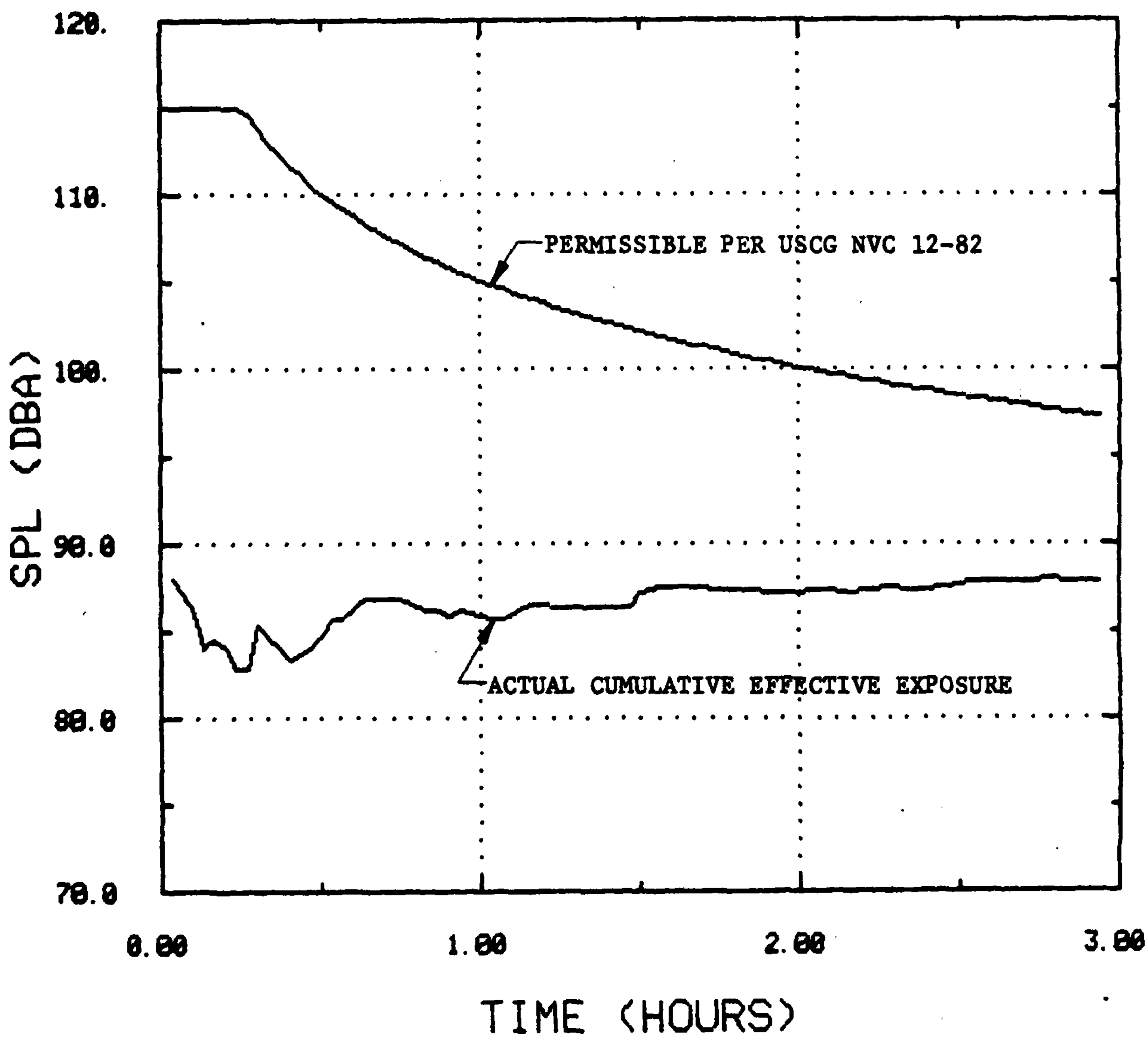
NOISE DOSIMETRY - SAMPLE 29



CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 29



NOISE DOSIMETRY - SAMPLE 30



CUMULATIVE EFFECTIVE EXPOSURE - SAMPLE 30

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